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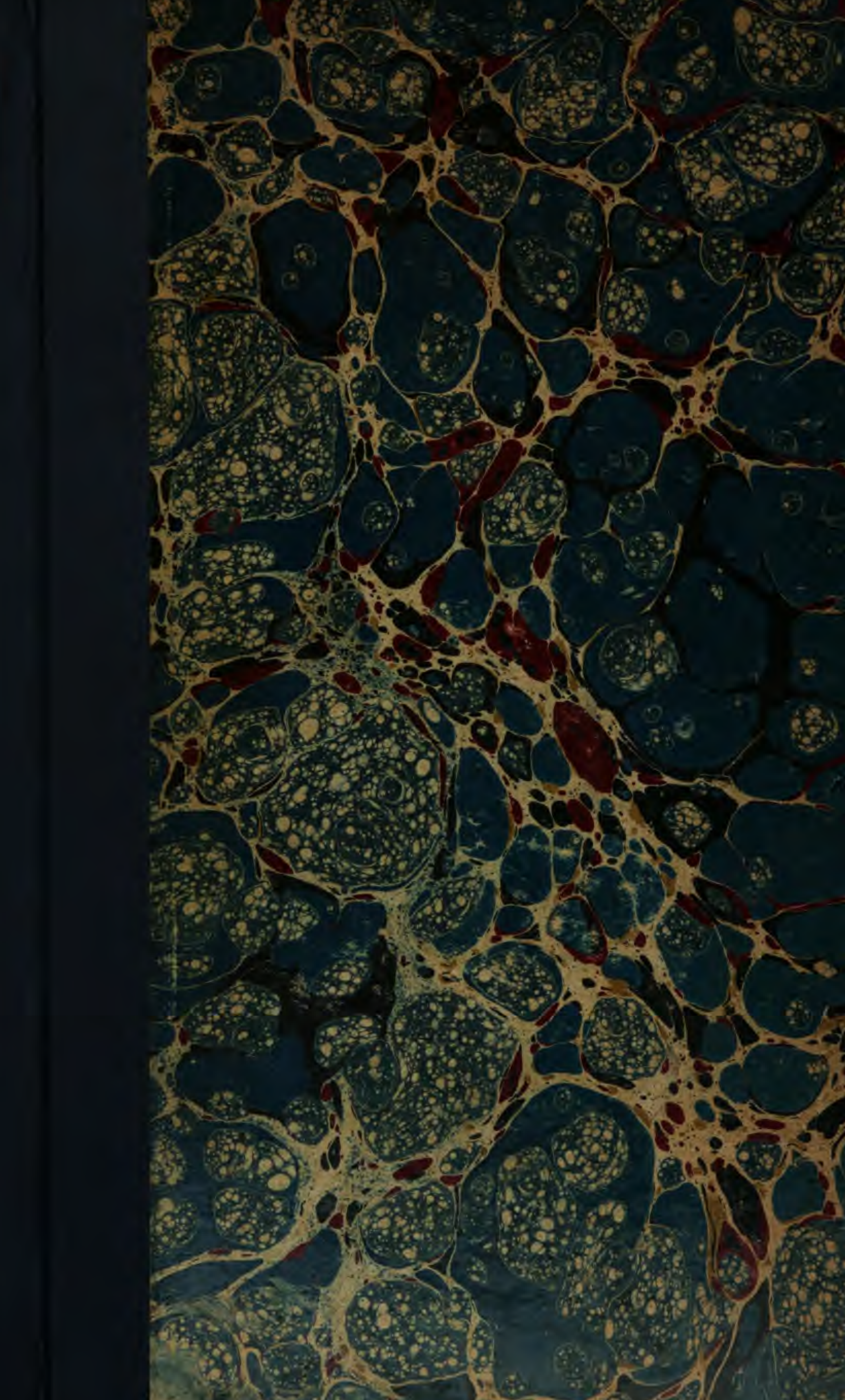

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63D CONGRESS } HOUSE OF REPRESENTATIVES { DOCUMENT
2d Session } { No. 876

REPORT ON COAL IN ALASKA FOR USE IN UNITED STATES NAVY

A LETTER FROM
THE SECRETARY OF THE NAVY

TRANSMITTING

REPORT OF SURVEY AND INVESTIGATION BY EXPERIMENTAL TESTS OF COAL IN ALASKA FOR USE ON BOARD SHIPS UNITED STATES NAVY, AND UPON COAL AND COAL FIELDS AVAILABLE FOR SAID PURPOSE

APRIL 3, 1914.—Referred to the Committee on Naval Affairs and ordered to be printed, with illustrations

WASHINGTON
1914

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LETTER OF SUBMITTAL.

NAVY DEPARTMENT,
Washington, March 23, 1914.

SIR: The naval appropriation act approved August 22, 1912, makes provision for the survey and investigation by experimental test of coal in Alaska for use on board ships of the United States Navy, and for report upon coal and coal fields available for the production of coal for the use of the ships of the United States Navy and any vessel of the United States.

In accordance with the foregoing I have the honor to submit herewith the report required by the above-mentioned act.

Very respectfully,

JOSEPHUS DANIELS,
Secretary of the Navy.

The SPEAKER, HOUSE OF REPRESENTATIVES,
Washington, D. C.

This report is divided into the following chapters:

(1) Reports of the geologists and mining engineer and a general statement by Dr. J. A. Holmes, director of the Bureau of Mines, under whose direction and supervision was placed all the technical matters pertaining to the geological and mining investigations of the field, as well as the securing of a tonnage of representative coal sufficient for test on board the armored cruiser *Maryland* and at the Engineering Experiment Station, Annapolis, Md.

(2) Brief description of the transporting of the test coal from Trout Creek (Bering River fields) to tidewater.

(3) Summary of the tests of this coal conducted by the U. S. S. *Maryland*.

(4) Tests of a portion of the same coal at the Engineering Experiment Station, Annapolis, Md.

(5) General conclusions and opinions of the Navy Department on the suitability of this coal for use of the ships of the United States Navy and any vessel of the United States.

REPORT OF THE NAVAL COAL EXAMINATION IN THE BERING RIVER FIELD, AUGUST TO NOVEMBER, 1912.

GENERAL STATEMENT.

By J. A. Holmes, Director Bureau of Mines.

ORGANIZATION AND PRELIMINARY WORK OF THE EXPEDITION.

The act making appropriations for the naval service for the fiscal year ending June 30, 1913, approved August 22, 1912, provided that of the total appropriation for depots for coal, etc., "$75,000, or so much thereof as may be necessary, may be used for the survey and investigation by experimental tests of coal in Alaska for use on board ships of the United States Navy and for report upon coal and coal fields available for the production of coal for the use of the ships of the United States Navy and any vessels of the United States."

With a view to carrying out this provision of the act, the Secretary of the Navy requested of the Secretary of the Interior that the Bureau of Mines take charge of all the technical operations in connection with this investigation. This request was acceded to by the Secretary of the Interior, and the necessary instructions were issued to the Director of the Bureau of Mines.

After a conference between the Director of the Bureau of Mines and the Chief of the Bureau of Steam Engineering, it was decided that the investigations to be carried on during the late summer and autumn of 1912 should be concentrated in the Bering River coal field, and that later, if circumstances permitted, plans would be inaugurated for a similar investigation in the Matanuska coal field.

In organizing the personnel of the expedition to carry out the purpose of the above act, the following selections were made:

Mr. R. Y. Williams, a mining engineer of the Bureau of Mines, who had been for some years the manager of coal-mining operations, and who was thoroughly experienced in the modern methods for safeguarding the lives of the miners, was placed in charge of the technical operations of the expedition. Mr. Sumner S. Smith, another of the mining engineers of the Bureau of Mines, who had also been a practical miner and a superintendent of a coal mine, as well as mine inspector in Alaska, was assigned as general assistant to Mr. Williams.

Mr. C. A. Fisher, a mining geologist of extended practical experience in the examination of coal deposits under the Geological Survey, and who had already made an exhaustive preliminary examination of a large part of the Bering River coal field, was added to the expedition, and to him was assigned the special duty of selecting the beds of coal to be tested in connection with the naval coal expedition. Mr. W. R.

Calvert, another mining geologist of considerable experience in the coal work of the Geological Survey, and subsequently in private practice, was appointed as Mr. Fisher's assistant for this preliminary examination of the Bering River field and for the selection of the special coal beds to be investigated.

Dr. J. O. Downey, passed assistant surgeon of the navy, was selected by the Navy Department to accompany the expedition as disbursing officer and physician, and Dr. Downey was also intrusted subsequently with the work of transporting from the coal field to navigable waters at Controller Bay the coal which was mined for the practical working test on board a naval ship.

These engineers and geologists were sent to the Pacific coast about the middle of August, with instructions to examine such of the coal deposits being worked in the State of Washington as resembled most closely the coal deposits in Alaska, as a preliminary to the beginning of the Alaskan investigations. Prior, also, to their departure for the Bering River field, these engineers and geologists, with the Director of the Bureau of Mines, made a careful examination of several previous reports of examinations of the Bering River coal field, including the examinations by the geologists of the Geological Survey, those made by the mining engineers (especially that of Mr. A. H. Storrs) sent into the field by private companies, and also the records of the examinations made by the Director of the Bureau of Mines and by three practical managers of coal mining operations who accompanied him in an examination of that field during August, 1911: Mr. T. H. O'Brien, general manager of the Stag Canon Fuel Co., Dawson, N. Mex., Mr. F. W. C. Whyte, manager of extensive coal mining interests in Montana, and Mr. L. T. Woole, the manager of extensive coal mining operations in Wyoming. Abstracts of this information were placed in the hands of this party, carried by its members into the Bering River field, and were doubtless of great value in connection with their later examinations.

During the latter half of August, Messrs. Fisher, Calvert, Williams, and Smith made a joint examination of practically all of the important openings or prospect holes in the Bering River coal field, and finally selected as the place most promising for the subsequent investigations the beds of coal exposed on Trout Creek in and about certain preliminary openings made on one of the Cunningham claims.

Meanwhile, as soon as possible after the passage of the act making appropriations for the Navy's coal expedition, a practical and experienced mine foreman, with 25 coal miners and other assistants, were selected from the coal mines in the State of Washington, where conditions most closely resembled those in Alaska; seven horses and a complete outfit of provisions and prospecting equipment and supplies were brought together and made ready for shipment from Seattle to Katalla, the point of landing and entrance to the Bering River coal field, and this main body of the expedition reached Controller Bay on September 6. While the men and horses of the expedition were landed safely, unfortunately a barge containing nearly all the supplies and equipment of the expedition was lost, and the work of the expedition was thereby seriously delayed and crippled. However, such equipment and supplies as could be purchased in the town of Katalla were immediately secured, and the expedition proceeded to Trout

Creek in the Bering River coal field, to the place selected for the detailed examination.

For several weeks following the arrival of the expedition more extended prospecting was done at a number of different points on Trout Creek with a view to determining more carefully the nature and the extent of the coal beds, and also with a view to deciding which particular bed or beds should receive the more extended subsequent examination. Meanwhile, also, a thorough survey of the Trout Creek region was made.

During the month of November the work of the expedition was devoted almost entirely to the extraction of the large sample of coal, estimated at something more than 800 tons, which was obtained for a more extended, practical, subsequent test under actual working conditions on board a naval ship. By the end of November this work had been completed, and the men of the expedition were transferred to Wingham Island, at the mouth of Bering River. From this point they sailed on December 13, and arrived at Seattle on December 20.

DETAILED EXAMINATIONS IN THE REGION SELECTED FOR TEST.

The engineers and geologists, for guidance in their field explorations, were given the following general specifications as indicating the nature of the coal desired by the Navy Department:

(1) Coal with a fair proportion of lump, free from slate, and low in sulphur;

(2) With a volatile matter not lower than 12 nor higher than 22 per cent, and preferably between 14 and 18 per cent;

(3) With ash not higher than 8 per cent; and

(4) With high fixed carbon and a high heating value—i. e., above 14,000 British thermal units.

After a study of the chemical analyses of samples collected from the different localities, and the preliminary explorations described above, the engineers and geologists agreed upon three locations as those most likely to yield coal of the character just described. One of these was on Trout Creek, one on Carbon Creek, and one on the east slope of Kushtaka Ridge. The location on Trout Creek, known as the "Tenino" claim of the Cunningham group, was finally selected as that one of the three giving the best promise of satisfactory results. Mr. Fisher describes this particular location as follows:

> This claim is traversed from north to south by Trout Creek, thus affording easy access to the coal, as there is a readily available passageway to and from tidewater. Moreover, there appeared to be at this locality the greatest quantity of available coal of the physical and chemical character required for Navy use. Opposite the Cunningham cabin on Trout Creek an 8-foot bed of hard coal had been opened, and about 850 feet farther downstream a 30-foot bed of similar coal had likewise been developed by a prospect entry. Nowhere else in the field could beds of such thickness, combined with the desired physical character, be found.

As the actual detailed examination of this region proceeded in connection with the extraction of the large sample of coal for subsequent ship test it was found that all of these beds upon which excavations were made proved to be lenticular or otherwise irregular in shape, and the coal proved to vary from high grade and fairly lumpy coal at certain places to a crushed coal, which at some points was high-grade and at other points a decidedly low-grade material.

EXTRACTION OF LARGE SAMPLE OF COAL FOR SHIP TESTS.

From the three most promising beds of coal at the location selected a sample, estimated at about 850 tons, was taken, and this coal was stored in sacks in the immediate vicinity of the openings, to be subsequently transported to tidewater and there placed on board ship for test under working conditions. The relation of these beds is shown on the accompanying sketch map.

From bed or tunnel No. 4 the larger portion (estimated at 674 tons) of this sample was extracted in a distance along the bed of about 120 feet, as it seemed to represent the best average conditions in that part of the Bering River field. This seam varied in thickness from 16 feet to 29 feet. It has an average dip of about 35° to the northwest. The character of a cross section of this bed is illustrated by the figures given in the three following cross-cuts or sections located about 30 feet apart along the length of the tunnel following the course of the bed.

Complete sections of seam opened in Tunnel No. 4.

Location.	First crosscut.	Second crosscut.	Third crosscut.
	Ft. in.	*Ft. in.*	*Ft. in.*
Hanging wall	(1)	(1)	(1)
Shale, soft	3 4	5 7	3 0
Coal	16 9	2 3	4 6
Shale	1 7	0 7	0 6
Coal	1 2	2 6	5 4
Shale	0 7	3 2	0 2
Coal	0 9	1 10	1 6
Shale	3 0	1 0	5 3
Coal	2 0	6 0	4 0
Footwall	(2)	(2)	(2)
Total thickness of seam	29 2	22 11	24 3
Total thickness of coal	20 8	12 7	16 4

Shale.

Sandstone.

From bed or tunnel No. 5 (see map) a portion (estimated at 154 tons) of this sample was taken because of the excellent quality of the coal and because it was desired to prospect further in order, if possible, to determine the cause of the unusual hardness of this coal over a distance of 130 feet from this opening. This tunnel contained 591 feet of entry and several crosscuts, one of which followed the coal for 69 feet. The coal sacked in this tunnel was taken from two crosscuts, one 84 feet and the other 52 feet from the drift mouth, each driven to the left of the entry. The sections measured as follows:

From crosscut 84 feet from drift mouth.

Roof, shale:	*Ft. in.*
Coal	2 8
Shale and dirt	8
Coal	2 7

Roof, shale:	*In.*
Shale	9
"Charcoal"	10
Floor, coal.	

From crosscut 52 feet from drift mouth.

Roof, coal:	*Ft. in.*
Coal	4 0
Coal and dirt	1 7

Roof, coal:	*Ft. in.*
Coal	1 3
Floor, coal.	

These sections, though they do not extend across the bed of coal, indicate the intimate association of shale and coal which is characteristic of many beds in this field.

From bed or tunnel No. 3 (see map) a quantity of coal (estimated at 20 tons) was taken to represent the average of the thinner seams of this field. It had been planned to obtain a large portion of the sample from this opening, but the sudden variations in thickness and the final complete thinning out of the coal discouraged further work.

The following sections, taken at 4-foot intervals, in this tunnel show the variations in the thickness of the coal bed:

	Section number.									
	7	8	9	10	11	12	13	14	15	16
	Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
Hanging wall, coal..	5 6	1 0	2 2	3 3	3 6	3 6	3 10	....	....	0 1

As indicated in the above cross sections, the relative proportions and the relative distribution in the coal beds of shale and coal vary considerably in the same bed and within comparatively short distances in the particular beds of coal from which the sample for the Navy test was collected, while the coal near the surface appeared to be reasonably solid and free from shale. Within comparatively short distances from the surface the transition of the coal into shale and from shale into coal was in places so gradual and the crushed coal and black crushed shale resembled each other so closely that the separation of the two could not have been made except through washing operations.

In future mining operations such separation, under conditions like those just described, can easily be made through the use of mechanically operated screens and a washery. The ample and well-distributed supply of water and the climatic conditions in the Bering River region are such as make the operation of coal washeries there entirely feasible.

Because of the relations described above between the shale and the coal, and the lack of facilities for separating the two, the several hundred tons of run-of-mine coal, mined during the month of November and subsequently sent on board the cruiser *Maryland* for practical test, contained an abnormally large percentage of this black shale and earthy material. The engineers superintending this work have been criticized for allowing this shale to get into the large sample for test; but having selected with care the original location and the beds of coal to be sampled, they felt it to be their duty to collect this sample as run-of-mine coal, excluding from it only such material as would be ordinarily excluded in mining. Not having at hand the facilities for either screening or washing this sample, the engineers were not able to remove from it much additional waste material that would be removed easily by screening and washing facilities, such as would be installed for use in commercial mining operations in this region; nor, indeed, did they detect the fact that so large a percentage of this black crushed shale was incorporated in the sample.

The apparatus for making chemical analyses in the field was lost with the other supplies off Controller Bay, and therefore the chemical analyses which it had been planned would be made from day to day as the work progressed, in collecting the sample for test on board ship, could not be inaugurated until a new set of apparatus was supplied after the larger part of this sample of coal had been collected.

THE TESTS OF THE COAL AND THE INTERPRETATION OF THE RESULTS OF THESE EXAMINATIONS AS APPLIED TO THE BERING RIVER COAL FIELD.

The sample of coal taken in connection with the work described above was tested as run-of-mine coal on board the cruiser *Maryland* by the engineers of the Navy Department. There were no facilities either in the coal field or on board the steamer for washing or screening this coal. A portion of the coal, approximately 50 tons, was saved for subsequent tests, after being both screened and washed, at the naval testing station, at Annapolis, Md.

The transportation of this sample of coal from the Bering River coal field to navigable water and the subsequent tests of the coal on board the cruiser *Maryland* and at Annapolis are to be described elsewhere by the officers of the Navy Department.

In the use of these results it should be remembered, first, that they apply to but a limited portion of the Bering River coal field, viz, the Tenino claim of the Cunningham group of claims on Trout Creek; and, second, that the tests on board the cruiser *Maryland* represent tests of "run-of-mine" coal without (owing to lack of facilities) there having been separated from the sample much shaly and other earthy material which, under ordinary commercial operations, would be separated from the high-grade coal through screening and washing operations.

It should be remembered, further, in this connection that while this particular location for securing the sample of coal for test on board ship was regarded by the engineers as one of the most promising localities in the Bering River field for the collection of such a sample, there are many outcrops of coal in the Bering River region the samples from a number of which when submitted to chemical analysis indicate coal of as high grade as the best from which this large sample was collected for the Navy test.

While, therefore, the results of this test are disappointing in so far as this particular locality is concerned, the tests can not be regarded as exhausting the possibility of securing in the Bering River coal field coal suitable for use on board ship and for various commercial purposes. And it should be remembered that in ordinary mining operations ample facilities can be installed in different parts of the Bering River field both for screening and for washing this coal, thus improving the quality of the coal. For washing purposes there will be an ample supply of water and the climate is sufficiently mild to make washing practicable during nearly if not quite all of the year. The cost of such washing operations, including the value of the fine coal lost in washing, would probably not exceed 30 cents, and might be less than 20 cents, per ton of coal washed.

The fact that the coal from this particular bed yielded, as was reported to be the case, in the ship's furnaces an ash which slagged on the grate bars and blocked the draft, furnishes no basis for condemning the entire coal field, as the ash from other coals in this field may behave quite differently; and even the ash from this coal might slag to a less extent in stationary furnaces for which a forced draft is not necessary.

The crushed condition of the coal at many of the outcrops in the Bering River field will increase the cost of mining and will lessen the value of the coal for some purposes, but it will facilitate the improvement of the coal by washing operations; and with the installation of modern mechanical stokers the more finely divided coal can be used to a much larger extent and with greater efficiency than was formerly supposed to be possible. This crushed coal can also be made readily available for coking or briquetting operations.

The following brief description of the Bering River coal field and its coals is reproduced from the report of the Alaskan Railroad Commission, 1913, page 57, paragraphs 2 and 3:

> The Bering River field, which is one of the two Alaska fields containing the largest amount of high-grade coal, lies about 25 miles northeast of Controller Bay and is drained by Bering River, from which it received its name. It is sometimes called the Katalla and sometimes the Controller Bay field. The surveyed parts of the Bering River field embrace 22 square miles underlain by anthracite and about 28 square miles underlain by semibituminous and semianthracite coal.
>
> The coal beds in this field which may be workable are from 3 to 25 feet thick, but through local swellings a much higher maximum thickness is attained. They are included in a great series of sandstones and shale, which are intensely folded and much faulted. In quality the coals vary from an anthracite, with an average of 81 per cent of fixed carbon, to a semibituminous, with 72 per cent of fixed carbon. The ash varies from about 2 to 10 or 12 per cent, the average from a number of analyses being from about 7 to 9 per cent. The bituminous part of the field includes much coking coal. The chemical composition of the bituminous coals of this region is similar to that of the best coals of the Appalachian fields, while the composition of the anthracite is but little inferior to that of the Pennsylvania anthracite.

COST OF THE FIELD EXAMINATIONS.

Both the cost of the field examinations and the cost of the transportation of the coal from the Bering River region to navigable waters were naturally higher than they otherwise would have been because of the lateness of the season at which the appropriation became available; the consequent rush with which preparations for the expedition had to be made; the loss of practically all of the supplies and equipment for the expedition in connection with the landing operations at Controller Bay; and the bad weather conditions throughout the entire period of the field work. The rains continued for almost this entire period.

The accompanying report by Mr. R. Y. Williams describes with more detail the field examinations and the mining conditions; and the report by Mr. C. A. Fisher describes in some detail the topographic and geologic conditions to be met with in any mining operations in this field.

The two attached maps (Nos. 1 and 2) indicate the location of the area in which the detailed examinations were made and the relations of this area to the topographic and geologic features of the Bering River region.

MINING CONDITIONS IN THE BERING RIVER FIELD, ALASKA, AS RESULT OF THE FIELD EXAMINATION OF THE UNITED STATES NAVY ALASKAN COAL INVESTIGATING EXPEDITION.

By R. Y. WILLIAMS, Mining Engineer.

ORGANIZATION.

The passage of the naval appropriation act by the Sixty-second Congress carried with it a provision for the investigation of Alaskan coal fields, which is as follows:

> Depots for coal: To enable the Secretary of the Navy to execute the provision of section 1552 of the Revised Statutes, authorizing the Secretary of the Navy to establish, at such places as he may deem necessary, depots for coal and other fuel for the supply of steamships of war, $500,000. That $75,000 of said sum, or as much thereof as may be necessary, may be used for the survey and investigation by experimental test of coal in Alaska for use on board ships of the United States Navy and for report upon coal and coal fields available for the production of coal for the use of the ships of the United States Navy and any vessel of the United States.

Pursuant to this act, the Secretary of the Navy requested the Secretary of the Interior to authorize the Bureau of Mines to take charge, for the Navy Department, of all the technical operations in connection with the investigation. The Bureau of Mines, in carrying out this request, selected two mining geologists, C. A. Fisher and W. R. Calvert, and two mining engineers, R. Y. Williams and S. S. Smith, to conduct the necessary field investigations in Alaska.

The areas to be studied in this investigation were the Bering River and Matanuska coal fields, which are the two most extensive fields of southeastern Alaska known to contain high-grade coals. The Bering River field is about 25 miles northeast of Katalla, between Controller Bay and the base of the Chugach Mountains, and the Matanuska field is on the Matanuska River, about 60 miles above its entrance into Cooks Inlet.

The object of this expedition was to determine whether or not there existed within these coal fields workable beds of coal suitable for naval uses which might be set aside by the President as a coal reservation for the Navy Department, and from which the Navy could obtain thereafter a supply of high-grade steaming coal for its own needs. The physical and chemical requirements of a coal suitable for naval uses were described as coming within the following limits: (*a*) A coal with a fair proportion of lump, free from "slate," and low in sulphur; (*b*) volatile matter 12 to 22 per cent, preferably 14 to 18 per cent; (*c*) ash 2 to 8 per cent, preferably much nearer the low than the high limit; (*d*) fixed carbon high; (*e*) heating value more than 14,000 B. t. u., and near 14,500 if possible.

The plan of operation decided upon was to proceed first with the investigation of the Bering River field, during the autumn of 1912, and at the close of that season to transport over the snow and ice into the Matanuska field the necessary equipment for beginning early in the following year an investigation of that area.

The personnel and equipment for the expedition was so planned as to include two mining geologists, two mining engineers, all to be selected by the Bureau of Mines, a Navy Department paymaster and surgeon, an experienced mine foreman, to be selected from the State of Washington, an assistant mine foreman, trained in rescue methods and first-aid work, 36 miners, two mine blacksmiths, a few packers, 10 pack horses, camp equipment, mine cars, rails, all necessary tools and implements, subsistence supplies, etc.

Fisher, Calvert, Williams, and Smith, as duly authorized representatives of the Bureau of Mines, were each placed in charge of certain phases of the execution of this work.

C. A. Fisher and W. R. Calvert, holding appointments in the Bureau of Mines as consulting mining geologists, were held responsible for the selection of the localities and the bed or beds from which a large sample of coal for the naval test was to be taken, these beds to be prospected later with a view of determining their workability and suitability for naval use.

R. Y. Williams, mining engineer in the Bureau of Mines, and S. S. Smith, also a mining engineer in the bureau and mine inspector for Alaska, were placed in charge of the details of the expedition, and in special charge of the prospecting to be done and the extraction of samples of coal to be procured for the naval test.

J. O. Downey, passed assistant surgeon, United States Navy, and paymaster and the representative of the Navy Department, was placed in charge of all matters pertaining to the health of the camp, and also of the disbursement of funds for the maintenance of the expedition. He was also intrusted with the details of transporting the coal sample from the mine to Seattle.

The five persons named above were requested to cooperate in every way possible to insure the success of the expedition.

PRELIMINARY INVESTIGATION.

In advance of the main body of the expedition and while weather conditions were still favorable, a general reconnoissance of the entire Bering River field was made by Fisher, Calvert, Williams, and Smith. The primary object of this preliminary investigation was to examine all the known prospect openings and to ascertain what were the most promising areas and beds in which more detailed surface and underground prospecting might be carried on and from which the large samples of coal for naval test might be obtained.

Owing to the great interest manifested with respect to the Bering River coal field, a number of detailed investiations of the area have been made both by the United States Geological Survey and by mining engineers in private employ. Mr. G. C. Martin, of the Alaskan Division of the United States Geological Survey, spent the season of 1905 and part of the succeeding summer in a detailed study of the field, the results of his study being available for this expedition in United States Geological Survey bulletin No. 335. During the summer of 1909 C. A. Fisher spent 30 days in the examination of the Cunningham group of claims for the Interior Department, the object of his investigation being to determine the coal or noncoal character of the respective claims. The results of his examination were published as part of the proceedings of the investigation by Congress, of the Forest Service, and the Interior Department. A. H. Storrs, a mining engineer of Scranton, Pa., also made a careful study of the Cunningham group of claims, the results of which were also published in the proceedings mentioned. In the summer of 1911 Dr. J. A. Holmes, Director of the Bureau of Mines, visited the field, and in connection with his general examination of the field obtained a number of coal samples for chemical analyses, took photographs, and made notes. A large amount of previously collected information was available, therefore, in regard to the Bering River field, comprising not only detailed data relative to the geology and coal occurrence, but also numerous analyses and carefully prepared maps.

With the above-mentioned information in hand, the preliminary survey party of four spent nine days (Aug. 24 to Sept. 1, 1912) on the ground investigating the entire field, the investigation reaching from the east side of Canyon Creek to McDonald's camp on Bering Lake.

The Bering River field is one in which rock exposures are rare except along the streams. The surface is almost entirely covered by a blanket of thick moss, grass, and brush above the timber line and below that horizon by a dense growth of spruce and hemlock in addition to the usual thick mantle of hill waste. Under these conditions it is evident that the best, if not the only, method of studying the coals of this field is by a detailed examination of all stream courses, along which the coal outcrops are in places fairly well exposed. Consequently all the large streams and their more important tributaries from Canyon Creek to McDonald's camp were followed and examined by the preliminary survey party during the nine days spent in the field. By this method those parts of the field presenting conditions that were classed as either undesirable or impossible were eliminated from the territory in which further and more detailed prospecting should take place.

After a thorough investigation of 150 surface outcrops and 22 tunnels, it was decided that the physical characteristics of the coal near the surface undoubtedly continue unchanged underground, that the coal is prevailingly soft, very much crushed and sheared, and that the areas containing coal of a character satisfactory for Navy purposes were restricted to not more than three locations: One on Carbon Creek in the vicinity of the English company's main camp; one unprospected location on the east slope of Kushtaka Ridge (also on the English company's claims); and one up Trout Creek on the Cunningham claims about 3 miles above the junction of that stream with Stillwater River. Of these localities, the last mentioned appeared to offer the most favorable conditions as regards geologic structure and quality and quantity of coal. The quantity available on the most favorable basis was only 25,000,000 tons, most of which was credited to two beds opened on the west side of Trout Creek, one being an 8-foot bed at station 51 and the other a 30-foot bed at station 9.

FIELD EXAMINATION.

Immediately following the arrival of the main body of the expedition on September 6, 1912, the detailed field examination on Trout Creek and the extraction of the large sample of coal was pushed as rapidly as possible until the completion of the work on November 29.

The detailed findings of the field examination may be presented as follows:

THE 8-FOOT BED, STATION 51.

This bed is exposed by a tunnel which follows the bed almost due west for 192 feet. A lens of coal over 8 feet thick extends from the portal to a point about 30 feet inside the tunnel where it pinches to 18 inches. The bed continues thin nearly to the face of the tunnel where the coal passes into carbonaceous shale between sandstone walls. On tracing the outcrop of this bed to the southwest, it was ascertained definitely that within approximately 600 feet from the tunnel entrance the bed is represented by 18 inches of coal and a considerable thickness of carbonaceous shale. At a still farther point the proportion of coal is even less, so that this particular bed is practically unproductive west of Trout Creek unless it so happens beyond the limit of present tracing that the coal replaces the shale, as is the case immediately adjacent to the stream bed. An endeavor was made to find the extension of this bed east of the creek but on account of the surface covering the attempt was unsuccessful, a drift of 10 feet failing to reach bed rock.

THE 30-FOOT BED, STATIONS 9, 30, 20 (1) AND (2), 17.

(Map No. 2.)

This bed was known locally as the "big vein" and had been more largely prospected than any of the Cunningham coals. The underground development consisted of a tunnel, tunnel No. 5, containing 591 feet of entry and several crosscuts, one of which followed the coal for 69 feet. This tunnel is on the west side of Trout Creek and 28 feet above the bed of the stream. On the surface on the east side of Trout Creek many old test pits were examined which seemingly had been dug in search of the continuation of the seam to the eastward.

The coal for a distance of 130 feet from the opening, station 9, was exceptionally hard for this field, lay at an irregular but steep dip, and had a strike with the direction of the tunnel. The thickness of the bed was very great, but its measurement was difficult because of the lenticular character of the bed at this point. In order to determine the cause of the unusual hardness over a distance of 130 feet from the opening and because of the excellent quality of the coal, a portion (estimated at 154 tons) of the large sample was taken from this tunnel, to which was given the number 5. The coal sacked in this mine was taken from two crosscuts, one 84 feet and the other 52 feet from the drift mouth, each driven to the left of the entry. The sections in these crosscuts measured as follows:

Crosscut 84 feet from opening.

Roof, shale:	Ft.	in
Coal	2	8
Shale and dirt		8
Coal	2	7
Shale		9
Charcoal		10
Floor, coal.		

Crosscut 52 feet from opening.

Roof, coal:	Ft.	in.
Coal	4	0
Charcoal and dirt	1	7
Coal	1	3
Floor, coal.		

The decision, which resulted from the investigation of the Trout Creek coals by the advance party, was that the large seam showing in this opening should be well prospected on the west side of the creek, as appearances indicated that the district to the southwest of the tunnel No. 5 was one of the most regular in the entire field. It was recognized, however, that the local irregularity of the bed strongly indicated that the coal might be merely a pocket caused by the fault in the bed of Trout Creek, and that this geological phenomenon probably caused the local hardness noted near the entrance to tunnel No. 5. An attempt was therefore made to trace the outcrop of this bed to the southwest. Of the openings made, there were believed to be points on this coal, as follows (see map No. 2):

1. Station 30 (mine No. 4). Strike S. 63° 45′ W. Dip 54° N.
   Hanging wall. Shale.
   Coal seam. Thickness, 16 feet 6 inches.
   Footwall. Sandstone.
2. Station 20 (1) and (2). Strike S. 10° W.
   Hanging wall. Shale.
   Coal seam. Thickness, 18 feet.
   Footwall. Sandstone.
3. Station 17 (1). Strike S. 18° W.
   Hanging wall. Shale.
   Coal bed. Thickness, 7 feet (upper 3 feet poor).
   Footwall. Sandstone.

On October 23, at station 30, men were detailed to the work of opening a new tunnel on this "big vein," this opening being called tunnel No. 4. This work, together with the prospecting at other points, was vigorously prosecuted until November 7, when it was finally decided that this location was the only one along Trout Creek where the main part of the large sample of coal representative of the bituminous coals of the Bering River field could be obtained.

The following sections were taken at 4-foot intervals as each timber set was put in place and represent the changes at the face of the tunnel as the work progressed and as the 674 tons of coal were loaded for the Navy test. It should be remembered that the bed was thick and that these sections, except as noted below, do not show the entire thickness of the bed.

Tunnel No. 4.

	Set No. —									
	6	7	8	9	10	11	12	13	14	15
	Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
Coal	3	1 5	2 0	2 3	3 3	2 6	10	....	9	....
Shale	1 7	1 0	1 2	10	1 9	1 2	1 7	2 0	2 2	2 2
Coal	1 5	4 7	6	2 1	3 10	8	1 2	1 10	3 0	4 3
Shale	1 0	4	10	7	....	1 10	7	2	3	1 1
Coal	1 5	1 10	3 10	2 7	....	3 0	9	1 9	8	1 4
Shale	5	....	....	....	....	....	3 0	5	8	....
Coal	1 10	....	....	....	....	....	1 0	10	1 2	....
Shale	....	....	....	....	....	....	....	1 6	....	....
Sacks from set	....	....	....	....	....	62	....	40	60	60

Tunnel No. 4—Continued.

	Set No. —									
	16	17	18	19	20	21	22	23	24	25
	Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
Coal	....	....	4 4	1 10	2 4	1 4	1 2	....	4	1 0
Shale	2 2	1 2	2	1 0	1 6	1 3	1 0	....	2	1 0
Coal	3 2	3 6	6	6 0	1 0	6 6	6 9	8 10	6 0	2 10
Shale	5	8	6	....	4	....	....	....	11	1 4
Coal	8	6	2 5	....	2 2	....	....	....	1 10	3 0
Shale	3 0	3 0	1 0	....	....	....	....	....	....	....
Sacks from set	50	49	64	88	94					

	Set No. —						
	26	27	28	29	30	31	32
	Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
Shale, etc	5 0	5 0	5 6	6 6	6 3	....	....
Coal	4 0	4 0	3 0	2 0	8	4 0	5 0
Shale	....	....	....	3	1 6	....	....
Sandstone	....	....	6	9	....	5 0	3 0

Complete sections of bed opened in Tunnel No. 4.

Location.	First crosscut, A-B.	Second crosscut, C-D.	Third crosscut, E-F.
	Ft. in.	*Ft. in.*	*Ft. in.*
Hanging wall	(1)	(1)	(1)
Shale, soft	3 4	5 7	3 0
Coal	16 9	2 8	4 6
Shale	1 7	7	6
Coal	1 2	2 6	5 4
Shale	7	8 2	2
Coal	9	1 10	1 6
Shale	3 0	1 0	5 3
Coal	2 0	6 0	4 0
Footwall	(2)	(3)	(2)
Total thickness of bed	29 2	22 11	24 8
Total thickness of coal	20 8	12 7	16 4

[1] Shale.

[2] Dandelion.

THE 6-FOOT BED AT STATION 28A.

This bed contained coal of fair quality and medium hardness and was prospected thoroughly because it appeared to contain coal that would satisfy the navy specifications. The examination showed, however, that the bed was of no value. At distances of 20, 40, and 100 feet long this outcrop from the showing of 6 feet of coal, this bed exhibited only 1 foot 8 inches of coal, 11 inches of coal, and 12 inches of carbonaceous shale, respectively. It was therefore necessary to abandon this bed.

THE BED AT STATION 28B.

At this point, Storrs states: "A very fine large seam could only be partially exposed owing to dirt slides." The reason for this was that the outcrop occurred at the crest of the ridge between the two gulches and the seam had been overturned. As a result, what appeared to be the footwall at a distance of about 12 feet from the hanging wall was, in reality, the overturned hanging wall. At a point 20 feet lower we again opened this bed, found the footwalls and hanging walls in place, and obtained a measurement of 6 feet across the bed.

No further work was done on this bed because of the topographical position of the bed, which would have made it necessary to drive a tunnel several hundred feet before finding sufficient cover for normal mining of the bed.

THE "14-FOOT SEAM."

The "14-foot seam" was examined by Mr. W. R. Calvert and the writer on September 11. Our conclusion was that the bed measured 8 feet, was very much crushed, and contained considerable shale which would render the analysis high in ash. Storrs gives the seam average as 8.17 per cent ash.

No further work was done on this bed, as we had no chemical outfit and the possibilities of obtaining a suitable Navy fuel did not look good.

BED EXPOSED IN TUNNEL AT STATION 4(1).

(See map No. 2).

This tunnel was started in broken coal on the east side of Trout Creek, 53 feet above the bed of the stream. The drift struck a fault 13 feet from the entrance and was deflected 15° to the south, a direction which it continued 24 feet, making the total length of the tunnel 37 feet.

The face of this drift was in sandstone, shale, and drag owing to a fault. The strata lay nearly flat, the dip being broken, but with a tendency toward the north. The measures to the north of the opening showed a broken and sharply folded condition which would cut off coal on dip.

It was deemed inadvisable to do any prospecting on this exposure.

SEAM EXPOSED IN TUNNEL AT STATION 4 (2).

(Map No. 2.)

The direction of this tunnel was N. 76° W. The drift continued 21 feet to a cave-in and seemingly 15 feet beyond it. There was a small amount of coal on the hanging walls (or normal footwall). The dip was 52° S., and the strike N. 76° W.

The coal is on the south leg of an anticline, the apex of which is seemingly in the gulch about 150 feet from the tunnel opening. Broken carboniferous shale appearing at the apex is probably connected with the coal in the drift.

The broken condition of the strata and the reverse dip proved this horizon unproductive.

SEAM EXPOSED IN TUNNEL AT STATION 207.

(Map No. 2.)

The rocks at the portal of this tunnel appear to have the normal dip and strike, but the bed farther in the hill has an irregular strike, as shown by the direction of the tunnel which follows the strike of the coal. The thickness of the bed is irregular and averages about 18 inches of dirty coal. At the face the strike is N. 85° E. and the dip 36° N.

The irregularity and small size of the bed discouraged further prospecting.

THE BED 30 FEET BELOW THE BIG VEIN.

Where exposed 30 feet below tunnel No. 5, this seam was represented by a bed of carbonaceous shale 6 feet thick.

At station 20 (3) and at station 20 (4) the bed measured nearly 8 feet of shale and coal with strike S. 10° W. and with a dip 35° to the northwest.

At station 19 this bed of coal was reduced to a thin streak of coal measuring 1 foot 6 inches in thickness.

Where exposed below tunnel No. 4 this bed showed 16 feet 6 inches of very clean coal, but prospecting proved that this bed thinned entirely out by the coming together of the footwalls and the hanging walls within 20 feet of the tunnel that was started as Navy expedition tunnel No 3½.

Obviously, prospecting showed that this particular bed had no value in this location because of the lenticular character of the deposit.

BED EXPOSED AT STATION 24 A (B) AND (C).

The bed exposed at this location measured 7 feet 6 inches of clean coal of excellent chemical quality. The bed appeared to be soft, and the likelihood of obtaining lump coal was doubtful; but the bed appeared to represent the general characteristics of the coal in this field, and prospecting was begun to locate the horizon of this bed at a point nearer Trout Creek.

This bed was opened at the location marked on the map No. 2 as tunnel No. 3. A tunnel was driven in on this bed a distance of 77 feet, and the following variations in the strata were noted at the entrance:

Distance from tunnel mouth.	Strike.	Dip.
At mouth	S. 62° W	78° E.
4 feet	S. 60° W	70° E.
10 feet	S. 22° W	75° 30′ E.
20 feet	S. 29° W	30° W.

The following sections were measured as the tunnel advanced (the timbers were spaced on 4-foot centers, and, as each set was placed in position, a section was measured across the bed to determine the thickness):

Tunnel Mine No. 3.

	Set No.—									
	7	8	9	10	11	12	13	14	15	16
	Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*	*Ft. in.*
Hanging wall	1 7	5 0	5 0	3 6	4 8	4 8	5 0	8 6	4 6	0 6
Coal	5 6	1 0	2 2	3 3	3 6	3 6	3 10	....	....	0 1
Footwall	1 6	3 0	2 0	2 0	....	....	....	....	4 0	8 2

On November 7 work was stopped on tunnel No. 3 because of lack of coal at the face. One hundred and eighty-two sacks had been loaded and delivered to the trail in case tests should be desired on this coal.

Extraction of the large sample of 855 tons of coal was made from the following openings:

Tunnel No. 4 (station 30, p. 6).—The major part of the sample (674 tons) was taken from this opening because, after it had been opened by the Navy expedition, it appeared to represent the best average conditions in the Bering River field. The bed varied in thickness from 16 feet 6 inches to 29 feet 2 inches and had an average dip of 35° to the northwest. Gangways, chutes or breasts, and crosscuts were driven in this mine, so that it was possible to observe the behavior of the coal under actual mining conditions. The necessity for heavy timberings, the presence of marsh gas in large quantities, the admixture of shale, igneous rock, etc., within the bed, the soft character of the shale roof, the large amount of water present in underground developments, and the small proportion of lump coal produced, were carefully noted.

The coal mined in tunnel No. 4 was loaded at the face into burlap sacks, each containing 220 pounds of coal. The sacks were tied and placed on a flat car which held 11 sacks. This tramcar was pushed by hand along a tramroad to the head of the No. 4 chute. The 11 sacks were then transferred to a sled, which operated down the chute and over the bridge, and lowered the coal 105 feet in elevation. The sled was controlled in descent and also brought up the hill by a rope and windlass at the head of the chute. This windlass was built of wood, was controlled by a wooden brake, and was handled with a 1¼-inch rope.

Tunnel No. 5 (station 9, p. 5).—Because of the excellent quality of the coal in this opening and in order to do some prospecting in the tunnel to determine the cause of the unusual hardness and the physical properties of the coal, 154 tons of coal were sacked and delivered to the Trout Creek trail.

Tunnel No. 3 (p. 9).—Early prospecting by the expedition indicated that the bed opened in this tunnel represented the thinner coals of the field and contained excellent fuel. Underground development proved disappointing, however, as has been described above. Arrangements had been made to handle this output by building a short tramroad and chute, so that the coal loaded in this tunnel might be delivered to the Trout Creek trail. As the bed pinched entirely out, only 20 tons of coal were placed along the trail.

Tunnel No. 3½ (p. 9).—Where opened below tunnel No. 4, the bed under the "Big Vein" measured 16 feet 6 inches and contained clean, hard coal. It was expected that this bed would produce an excellent fuel, and development work was begun. Only about 7 tons were sacked before the foot and hanging walls came together and pinched the coal entirely out.

The following table shows the locations, the number of sacks, and the tonnages of coal taken for the Navy test:

Location.	Sacks.	Tons of coal.
Opening No. 4	5,982	674
Opening No. 5	1,400	154
Opening No. 3	182	20
Opening No. 3½	65	7
Total	7,629	855

During the field examination, the following conditions affected the work of the expedition:

1. LOSS OF BARGE, PROVISIONS, AND EQUIPMENT.

On the morning of September 6, 1912, in Katalla Roadstead, Alaska, a 100-ton barge was loaded from the steamship *Mariposa* with personal baggage valued at $1,320, and supplies and equipment valued at about $9,000, which had been purchased for this expedition. About 11 o'clock, the 25-horsepower gasoline launch *Pioneer* took this barge in tow in order to effect a landing. Because of a severe storm which had been raging since the previous afternoon, the launch was unable to handle the barge which broke loose and was blown out to sea. The barge was not recovered. As a result of this loss, the expedition began work under serious handicaps.

2. TRAIL BUILDING.

The encampment on Trout Creek is 4¼ miles from the "cache" at the canoe landing on Stillwater Creek. During the Cunningham activities a narrow pack trail was built to connect these two points. Because of the rainy weather conditions in September, 1912, and because of the character of the soil and tundra over which this trail passed, the condition of this trail was so soft that a very large amount of work had to be accomplished before the pack train could make daily trips. The work consisted of (*a*) widening the trail so that a sled or go-devil or lizard could be used; (*b*) straightening the trail so that the rails and lumber could be hauled on the sleds; (*c*) building corduroy bridges at the most swampy places; and (*d*) throwing in brush, spruce boughs, rock, etc., at other soft places to give a foundation to prevent the miring of the horses.

The so-called "cache" was a wreck at the time of our arrival, and as the prospectors and miners filled the Trout Creek cabin, the gang working on the trail had to return to Stillwater cabin for housing each evening. The weather prevented caring for the men by pitching tents along the trail. As a result, the trail builders had to walk over marshy land an average of 3 miles before starting and after quitting work each day.

It was necessary to build the trail not only in order that 100 tons of provisions and supplies might be taken from the "cache" to the Trout Creek cabin, but also that the 855 tons of coal might be sledded during the winter from the mines to the canoe landing near the "cache."

3. CAMP CONSTRUCTION.

About 1903, during the early coal activities, a log cabin was built on Trout Creek. The ground floor of this cabin was used by the members of the expedition as a cook house, and the attic furnished sleeping quarters for 12 men. A large sleeping tent, 18 by 30 feet with accommodations for 28 men, a commodious wash tent, 16 by 24 feet, and three residence tents, each 12 by 14 feet, were built by the expedition.

In building this encampment, the following conditions affecting the health and safety of the men were considered.

(*a*) *Heavy winds.*—All trees within 200 feet of the camp were felled; the tents were fitted over a strong framework of rough lumber.

(*b*) *Heavy snows.*—In addition to having the tents fitted over the strong framework of rough lumber, the location was chosen with regard to safety from snow slides.

(*c*) *Heavy rains.*—The tents were built on raised platforms and were surrounded by ditches which emptied into the covered drains from the wash tent. This drain emptied in the creek below the cabin.

(*d*) *Water supply.*—The water supply was obtained from a creek along which there was no travel of men and which entered Trout Creek 180 feet above the camp. This water was delivered through a 1½-inch pipe to the wash tent and to the cook house.

(*e*) *Sanitation.*—The toilet facilities were located at a lower level than the camp and at a place where the wash would enter the creek below the camp.

There were unavoidable delays and difficulties encountered in building this camp, as follows:

(*a*) Delay in choosing location, due to the fact that the work of prospecting had first to be prosecuted to such an extent as would indicate the place where the large sample of coal was to be mined.

(*b*) Delay caused by lack of tools, as all the carpenter's tools were lost on the barge, September 6, and second-hand equipment had to be purchased from the several camps in the vicinity.

(*c*) Delay caused by lack of materials, as most of the lumber was lost during the floods of September 12, 21, and 27.

(*d*) Delay due to inability to transport floor lumber until the near completion of the trail.

(*e*) Delay due to inability to work many men on the camp until some of the tents were completed.

(*f*) Difficulty in constructing a camp by the use of an inadequate supply of very old second-hand tools.

(*g*) Difficulty in having to frame each tent with rough lumber, which was hard to obtain.

(*h*) Difficulty in having to perform the camp construction during a continuous downpour of rain.

The camp when completed was very comfortable and was appreciated by the men. The sleeping tent was equipped with 28 bunks built of canvas and poles cut in the woods and was heated by two Sibley stoves. The wash tent contained running cold water and a wooden tank of 350-gallon capacity for warm water, which was heated by means of a coil in a homemade coal stove. The blacksmith built this stove from a 50-gallon gasoline tank. The floor of the tent sloped toward the center and all waste water was delivered into a covered ditch which drained into the creek.

4. THE OPERATION OF PACK TRAINS.

In order to perform the transportation of material and supplies from the head of navigation to the location of the permanent camp, it was considered necessary, before the expedition entered the field, to procure 10 horses. Three of these were to have been purchased at Katalla and seven at Seattle. One of the Katalla horses was considered unfit for this service and was not purchased, and one of the others was killed on the trail August 29. Of the seven Seattle horses, one was drowned September 13, one was totally disabled September 22, one developed poll-evil from a wound received September 4 on the steamship *Mariposa*, and one was rendered only 50 per cent efficient because of a cold caught on the trip on the *Mariposa*. This brought the number of horses continuously available for our work down to the average of five.

The work accomplished by this pack train was the transportation of all food supplies, tools, and mine equipment from the "cache" on Stillwater River to the mines and camp on Trout Creek. The length of haul was 4½ miles. One of the most important items was the transportation of 8,000 empty coal sacks, which required the use of the entire pack train for one month.

The operation of the pack train was made difficult by the following conditions:

(*a*) The trail was very soft and heavy, due to the continuous rain.

(*b*) A number of horses were unfit for continuous service, owing to injuries received prior to the beginning of packing.

(*c*) Many articles, such as the coal sacks, were made heavy because they had become wet, due to the rain and the lack of tarpaulins.

(*d*) It was impossible, except on a few occasions, to make more than one round trip per day.

It had been planned to transport coal from the mine to the canoe landing on the return trips of the pack train. This, however, was deemed inadvisable, because of the condition of the horses and of the heavy trail. At best, only 10 to 12 tons of coal could have been packed during the field work of the expedition if each horse had carried 100 pounds per trip, and this small amount, when compared with the 855 tons mined, did not seem to warrant the time of the men and the danger of overworking the horses.

5. CONSTRUCTION OF THE SURFACE PLANT.

The surface plant consisted of the following, and was constructed under the same difficult weather conditions as have been described above:

(*a*) Blacksmith shop, constructed of a 12 by 14 foot tent and containing a homemade forge, bellows, and anvil obtained from the Cunningham cabin on Clear Creek, and tools, most of which were made by the smith.

(*b*) Powder house for storing explosives.

(*c*) Tramroad and chute for opening No. 3.

(*d*) Tramroad (150 feet long), chute, and bridge (144 feet long) for opening No. 4.

(*e*) Trackage and storage room for sacks from opening No. 5.

MINING CONDITIONS.

The following statements of the conditions affecting the mining of coal in a portion of the Bering River field are based on the preliminary investigation and the field examination by the United States Navy Alaskan coal investigating expedition during the fall of 1912.

The topography and geology of this field are presented in detail by C. A. Fisher of this expedition in an accompanying report.

The transportation and markets are discussed in the Report of the Alaska Railroad Commission, 1913.

Gangways, chutes or breasts, and crosscuts were driven in the openings by this expedition, so that it was possible to observe the behavior of the coal under actual mining conditions. The necessity for heavy timbering, the presence of marsh gas in large quantities, the admixture of shale, igneous rock, etc., within the beds, the soft character of the shale roof, the large amount of water present in underground developments, and the small proportion of lump coal produced were carefully noted and the information used in forming estimates of the cost of producing coal in this field.

1. THE QUALITY OF THE COAL.

(*a*) *Chemical analysis.*—On chemical analysis some of the Bering River coals are shown to be of excellent quality. When care is used in excluding all shale and intrusive material from the sample these coals show low ash, low moisture, 10 to 25 per cent volatile matter, and high calorific value.

(*b*) *Physical properties.*—The coals in this field are prevailingly soft. This physical condition is probably due to the crushing and shearing strains induced by the geologic disturbances. Exceptional locations, however, have been found where the coal is sufficiently hard to yield a fair percentage of lump; but seemingly this hardness occurs only in the immediate vicinity of faults where the break in the strata has relieved the crushing pressure and permitted the coal to maintain its original hardness.

In mining operations, judging from conditions thus far found, the loss of coal will be high. It is doubtful whether, under present mining methods, a recovery of over 25 per cent will be possible from a number of the most favorable beds. It is believed that the coal of some beds will be found so soft and crushed that the coal will "flow" or "run" under pressure induced by the mining operations, so that it would be difficult to maintain pillars. It is possible that some modification of existing methods of mine packing could be applied that would insure a high percentage of recovery; but such a method would necessitate the quarrying of rock or the excavation of gravels on the surface and delivery into the mine of the packing material and would render the cost of mining high.

2. IRREGULARITIES OF THE STRATA.

Much information was obtained concerning the irregularities of the strata. In certain localities in this field the strata are so broken that it may be necessary to follow the practice of the metal miner and block out the vein in order to develop the coal sufficiently to maintain the output. This may call for the driving of tunnels and upraises through rock without the production of coal. The effect of these geologic disturbances on the mining conditions will be to increase to an important item the cost of "dead work."

3. CHARACTER OF FOOTWALLS AND OF HANGING WALLS.

Each footwall in tunnels Nos. 2, 3, 4, and 5 is a firm sandstone with a dip of over 40°. The contact between the footwall and the coal is a smooth surface from which the coal parts easily. The hanging walls are invariably shale which is soft, slippy, and clodlike. There is no well-defined line separating the shale hanging wall from the coal, but instead the transition from coal to shale is gradual. A roof of this character is difficult to hold, especially in a country of broken strata; and the water seepage is great.

4. METHANE (CH_4).

The amount of methane or marsh gas exuding from the coal is large. In both tunnels No. 4 and No. 5 this gas was found in large quantities in gangays and chutes beginning at a distance of 80 feet from the tunnel opening. The occurrence of this gas, combined with other information concerning mining conditions, indicates that the coals in this part of the Bering River field will yield under development an amount of methane that will be difficult to handle, especially below water level where safety lamps will be required.[1]

5. MINE WATER; COAL DUST.

Evidence tends to show that the mining of the thick beds will produce much dust and that water will be encountered. The coal in tunnels No. 4 and No. 5 was 16 to 30 feet thick, and where entries and chutes had been driven in the footwall the face was always dry and dusty.[2] In the crosscuts, however, which were driven horizontally to prove the seam, much water was encountered as soon as the hanging wall was reached. It is reasonable, therefore, to predict that for this field of heavy rainfall a heavy pumping charge, below water level, must be added to the cost of mining.

6. MINE PLANS.

The dip of the beds upon which work was done averaged 40°, and the method of mining usually adopted in similar conditions is known as the "pillar-and-breast" method with water-level gangways driven approximately with the strike of the bed and breasts driven directly up the pitch or at about right angles to the gangways. The Navy expedition found under this method that in tunnel No. 4, 5 to 7 feet was the maximum width that could safely be used for the breasts. The gangways were driven with a 5-foot collar, the total width of coal extraction being 7 feet.

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[1] Methane, or marsh gas (CH_4), when mixed with air between the proportions of 1 to 20 and 1 to 7, explodes when ignited.

[2] Dry coal dust when brought into suspension in the mine air is often explosive and may be ignited by a blown-out shot, an electric arc, or an open flame.

It may be practicable in this field to use the longwall method of mining supplemented by a suitable system of hydraulic packing that would fill the workings with sand or gravel as fast as the coal is removed. This method would result in a larger extraction per foot-acre and a lower mining cost.

7. MINE TIMBER.

The hills and ridges up to the timber line (1,800 feet in elevation) are covered with a dense growth of spruce and hemlock. These trees are usually tall, straight, and knotty. Many trees are killed each year by porcupines, which gnaw the bark in a complete circle around the base of the trunks. Because of the shortness of the summer, the Alaskan trees are rather brittle, and the heavy winds cause many windfalls.

There is not sufficient timber on the surface of most claims to meet the needs of operation of the coal mines that would be necessary to develop fully those claims. It is estimated that from one-third to one-half of the mine timber will have to be imported in case mining activities are established.

The method of timbering adopted by the Navy expedition to make mining safe is known as "fore-poled or fore-lagged timber sets." In the "pillar-and-breast" method of mining, "breast boards" will be necessary in the driving of many chutes and breasts to prevent the running of the coal which would contain large amounts of the soft roof material.

The amount of timber that will be required per ton of coal produced will be large. The actual amount of timber used by the Navy expedition in the "pillar-and-breast" method of mining was 38.6 feet b. m. per ton of coal. This figure may be reduced, possibly to 25 feet b. m., in case a successful modification of the longwall method of mining can be applied. If the Government should operate these mines, the cost of timber in place in the mine should not exceed $20 per 1,000 feet b. m.; for a private company that had to purchase the timber the cost would probably reach $30 per 1,000. These figures include all timber items, both labor and supplies.

8. MINE HAULAGE.

The haulage problem may be attacked in either of two ways:

(*a*) Each bed may be treated as a separate development. Under this system the average amount of tonnage that will pass over a yard of constructed haulageway will be small and the cost per ton high.

(*b*) Long development tunnels may be driven through rock across the pitch of the bed. Under this method the average amount of coal passing over a yard of constructed haulageway will be large, but installation and maintenance costs of the long haulageways will be high, and the cost per ton also a large item.

It is estimated that the haulage cost for a large tonnage will approximate 10 cents per ton.

9. COAL WASHING.

It is believed that the coals of this field, if opened on a commercial scale, will require washing because of (*a*) the foreign material within the beds, such as shale, sand accretions, and igneous intrusions;

(*b*) the prevailing soft nature of the coal, with little or no lump; and (*c*) the probability of the admixture of roof material, owing to the generally soft and slippery nature of the shale hanging walls. All of the bituminous coals in the Rainer field, Wash., are washed because of the existence there of conditions similar to those just described.

10. BRIQUETTING THE COAL.

If the coals from this field are found, from actual firing tests on naval vessels, to contain too small a percentage of lump coal to render their use successful as fuel for United States ships, it is quite possible to briquet this coal, and produce thereby a fuel suitable for the needs of the Navy and for domestic purposes. This method of treatment is applied to a considerable extent to the soft Cardiff coals for the use of the British Navy at Victoria. In case the Bering River coals be so treated, the binder would probably be obtained from the asphaltic oil district of southern California; and it would be advisable to have the briquetting plant near the docks and equipped with suitable arrangements for handling raw coal and for storing briquets.

11. LABOR COSTS AND EFFICIENCIES.

At present the cost of labor in this field is high; emergency work is valued at $1 per hour, and steady employment at $5 per day, including subsistence. Furthermore, labor is rendered less efficient because of weather conditions.

The present high cost of labor may be partly overcome by the establishment of a permanent industry in this field; but the climatic conditions will continue to handicap all outdoor work, and the interest charges due to the high development cost must be borne as an operating expense for a considerable number of years.

SUMMARY OF MINING COSTS.

It is assumed in the following tabulation of the above estimates—

1. That the Government will own and operate coal mines and timber claims and that royalties and amortization of capital are not required.
2. That it will be possible successfully to apply the long-wall method of mining combined with some form of hydraulic packing that will reduce the amount of timber per ton 25 per cent over that required by the pillar-and-breast method.
3. That for mines owned or leased by private capital the following items must be considered:

	Cost per ton.
Timber supplies	$0.25
Royalty	.10
Depreciation of plant	.10
Total	.45

4. That these figures are subject to variation, depending on the tonnage and on further field examination.

	Cost per ton.
Mining and loading at face	$0.75
Timbering—all labor items	.50
Advance work—rock tunnels, etc	.50
Care of mine—cleaning falls, stopings, ventilation, lighting, etc	.30
Haulage—underground and hoisting	.15
Pumping and sprinkling	.05
Power—steam or water power	.10
Outside plant—tramming, dumping, screening, cleaning, picking, etc	.15
Superintendence, engineering, bookkeeping, etc	.10
Total cost f. o. b. cars or washery	2.60

CONCLUSION.

In a consideration of the present value of the Bering River field as a source of fuel supply for United States ships the enormous quantity of coal deposited and the excellent chemical quality of the fuel is generally admitted. The occurrence of these deposits, however, is everywhere lenticular and irregular, and no location has been found where any bed maintains uniform conditions of thickness and characteristics for any considerable distance. In a measure, the chemical purity is offset by the friable physical quality of the coal, which may make it impossible to produce from the mines any considerable proportion of lump coal; and the fact that strata within which the beds of coal occur are disturbed to such an extent will make the cost of mining high.

GEOLOGY OF THE BERING RIVER FIELD AND ITS RELATIONS TO COAL MINING CONDITIONS.

By C. A. FISHER and W. R. CALVERT, mining geologists.

TOPOGRAPHY.

(Map No. 1).

The Bering River coal field as a whole presents two distinct types of topographic development. It contains irregular rugged hills of moderate elevation and about an equal areal proportion of featureless lowlands traversed by numerous small streams or occupied by arms of glaciers or by glacial lakes of considerable size. The transition from hills to lowlands is abrupt and clearly outlines the two topographic Provinces. The maximum relief in the coal field proper is about 3,000 feet, but most of the ridges rise to about 2,000 feet above sea level. On the northwest and southeast the field is bordered by glaciers, on the northwest by Martin River Glacier, and on the southeast by Bering River Glacier, both of which are derived from the Chugach Mountains to the north. Broadly viewed, the Bering River coal field constitutes a part of the foothill zone between the Chugach Mountains and the coast.

The hilly parts of the field are characterized by moderately high, steep-side, narrow-topped, irregular ridges, separated by deep canyon-like valleys. The prevailing trend of the more prominent ridges, such as Carbon, Canyon Creek, Cunningham, Kushtaka, and the ridge to the west of Shepherd Creek is northeast or roughly parallel to the tributary drainage. In general the eastern slopes of these ridges are steep, whereas the western slopes are less precipitous. Most of the hills or ridges are gashed by numerous small canyons on their lower slopes, higher up are rounded peaks or shelving areas, and then come bare cliffs eroded at the top into sharp irregular peaks and ridges. It is in the deeply eroded canyons and in the faces of the bare cliffs that the best exposures of coal are found.

The lowlands are traversed with a network of rivulets which empty into small swamps or the larger lakes. The lowland is only a few feet above sea level, and it is characterized by featureless grass-covered flats which merge seaward through a zone of swamps into shallow lakes or the tidal flats surrounding the bay.

The trunk drainage course of the field is the Bering River, which flows in a general southwest direction from First Berg Lake to the coast, a distance of about 20 miles. Its principal tributaries from the north, and the ones that drain the Bering River field proper, are Canyon, Stillwater, and Shepherd Creeks. Canyon Creek has its principal source in Martin River Glacier but receives a number of small tributaries from either side throughout its course across the east part of the field. In the upper part of its course this stream follows a narrow canyon, which, to the southward near the confluence of the creek with Bering River, opens on a wide flat. Stillwater Creek, the outlet of Kushtaka Lake, is a short stream but carries a large flow of water. Kushtaka Lake is fed from an arm of the Martin River Glacier. The creek receives two tributaries from the north, Clear and Trout Creeks, which drain either side of the Cunningham Ridge. On both of these creeks, but mainly on Trout Creek, much development work has been done on the coal beds. Shepherd Creek crosses the western portion of the field, connecting Lake Charlotte with Bering Lake. It receives a number of tributaries, of which Carbon Creek from the east is the largest. It is on this stream that many of the English company's coal openings have been made. Most of the tributary streams that drain the coal field proper have relatively low gradients to near their head, where the gradients become steep. This topographic feature not only offers easy access for railroad lines, but places above water level a large aggregate tonnage of coal in the adjoining ridges. The largest tributaries from the east which enter Bering River are the Gandil and Nichawak Rivers, both of which are outside the coal field proper and therefore unimportant in the present consideration.

The region presents at least three types of vegetation which bear a close relationship to the topography. The field, as a whole, is only partly forest clad. The lower slopes of the hills and some of the sandy flats support a dense growth of evergreens, mainly spruce and hemlock, the spruce usually attaining a large size. Above timber line, which is about 1,500 feet, the surface is bare in places, but is largely covered with grass, devil's club, small bushes, and a stunted growth of spruce and alder. On the lowlands the vegetation consists mainly of grass and bushes, but deciduous trees, mainly cottonwoods and alders, grow along the watercourses.

LAKES.

The larger lakes of the field comprise Bering, a shallow tidal lake or lagoon in the southwestern part; Kushtaka, a deep glacial lake near the middle; and First Berg, also a deep glacial lake in the northeastern part of the field. In addition to these, there are three smaller glacial lakes, known as Charlotte, Tokun, and Deadwood, in the northwestern part of the field.

GLACIERS.

As previously stated, the Bering River coal field lies between the Martin River Glacier on the north and the Bering River Glacier on the south. An arm of the former, known as Kushtaka Glacier, extends into the field from the north nearly to Kushtaka Lake, occupying an area of about 5 square miles, and in the extreme northeastern part of the field there is a slope glacier on Carbon Mountain covering an area of about 4 square miles.

TRANSPORTATION.

The natural route of transportation from Controller Bay to the Bering River coal fields is up the wide glacial flats along Bering River, especially above the union of Bering River with Bering Lake. Below this point two alternative routes present themselves—one down Bering River proper and another across Bering Lake, over a low divide, and thence down Katalla River to the vicinity of Katalla. Water transportation by way of Bering River and its principal tributaries, or by Bering Lake, is practically the only way at present of reaching the coal field from Controller Bay, and it is along the wide glacial flats bordering this stream that most of the preliminary surveys of the various railroad companies have been made, as is shown by the transportation map accompanying this report.

Six different railroad companies have surveys extending from Controller Bay to different parts of the coal field. These companies are known as the Alaska-Pacific Railway & Terminal Co.; Copper River & Northwestern Railway; Controller Railway & Navigation Co.; Controller Bay & Bering Coal Railway; Bering River Railroad; Kushta-ka Southern Railway. Two of these companies, the Controller Railway & Navigation Co. and the Controller Bay & Bering Coal Railway, have made two distinct surveys, an old and a new. The course of these different surveys, their terminal points, and the different parts of the field that they enter are shown on the map accompanying Senate Document No. 12, Sixty-second Congress, first session (Apr. 26, 1911).

The route up the valley of Bering River from Controller River to the coal fields presents no special difficulties in railroad construction, other than that the lower part is through tidal flats and much of the remainder is over low, swampy marshes crossed by numerous glacial streams, which would necessitate a large amount of bridge work that would be subject to damage from the not infrequent and often severe floods. The crossing of Bering River above Bering Lake and the crossing of Bering Lake on pile bridges would be portions of the construction that would be relatively expensive. Shepherd, Stillwater, and Canyon Creeks have eroded deep valleys far back into the interior of the coal field, and these valleys enable railroad lines to enter without serious difficulty nearly all parts of the field.

It is difficult to estimate the cost of railroad construction in a region of this character, so remote from a base of supplies and having so many unusual and untried physical conditions. Judging from what railroad building has been done in this general region, the cost would be more than double the cost per mile through a country of similar character in the States. In addition to the high first cost of a railroad in this district, there must be allowance for heavy maintenance charges, as has been found by experience in operating railroads in southeastern Alaska.

As to the cost of constructing a harbor suitable for handling the production of this coal field, experience has shown that a very large expenditure of money would be required and that the final results would be uncertain.

GEOLOGY.

(Map No. 1.)

STRATIGRAPHY.

The rocks that outcrop in the Bering River coal field are of two general classes: (1) Loose, unconsolidated sediments of recent deposition, which, for the most part, occupy the lowlands; and (2) the indurated and highly folded shales, sandstones, and coarse arkose found on the hills. The indurated rocks are intruded to some extent, especially in the Carbon Mountains district, by igneous rock, mainly diabase and basalt in the form of dikes and sills. The total thickness of the sediments in the Controller Bay region probably exceeds 12,500 feet. They comprise graywackes, shales, etc., of pre-Tertiary age, and the Katalla, Stillwater, Kushtaka, and Tokum formations, of Tertiary age. The four last-named formations outcrop in the Bering River coal field proper, but probably only the Kushtaka is coal-bearing, and is therefore the only one of immediate concern in the present investigation. The age, formation, character, thickness, and general succession of the rocks are shown in the following table:

General section of rocks of the Controller Bay region.

Age.	Formation name.	Character of rocks.	Thickness.
			Feet.
Quarternary		Stream deposits, probably in part underlain with marine sediments.	0-500±
		Sediments and abandoned beaches of glacial lakes	0-200±
		Morainal deposits	0-100±
		Marine silt and clay	100
Tertiary or later		Diabase and basalt dikes	
Tertiary	Tokum	Sandstone	500
		Shale	2,000+
	Kushtaka	Arkose with many coal beds	2,500±
	Stillwater	Shale and sandstone	1,000±
	Katalla [1]	Conglomerates and sandstones and shales, some of which are conglomeratic.	2,500
		Sandstone	300
		Shale concretionary and with a glauconitic bed at the base.	2,000
		Sandstone	1,000
		Shale	500+
Pre-Tertiary		Graywackes, slates, and igneous rocks	

[1] The position of the Katalla formation with reference to the other Tertiary formations is not definitely established.

The Kushtaka, which is the principal coal-bearing formation of the field, consists of alternating beds of shale and of coarse arkose or sandstone. The rocks are indurated throughout. Above the middle of the formation there is a heavy bed of coarse arkose, which causes waterfalls wherever streams cross its outcrop, and, owing to its hardness, has resisted erosion sufficiently to cause shelving on the hillsides. The entire formation has a thickness of 2,500 feet, and overlies, in presumable conformity, the Stillwater formation, which is believed not to be coal bearing. Normally the Kushtaka formation is overlain by the Tokun formation, which is also not coal bearing, but on Shepherd Creek overthrust faulting has brought the Tokun in contact with the Stillwater formation.

The distribution of the Kushtaka formation is shown on the geologic map (No. 1) accompanying this report. It will be seen by reference to the map that the formation occupies much of the northern part of the land area lying between the Bering River and Martin River Glaciers.

The areal extent of recent unconsolidated sediments within the area occupied by the Kushtaka, or coal-bearing, formation is comparatively small.

STRUCTURE.

Viewed broadly from some commanding point in the Bering River field—from Kushtaka or Cunningham Ridge, for example—the structure appears to be fairly uniform, for the persistent sandstone member forming the falls on the various western affluents of Clear Creek can be noted along an extent of several miles without marked change in direction of trend. This appearance of uniformity is very illusive, however, for a closer study of the field demonstrates that the area has been subjected to intense dynamic stresses, and that almost every portion gives evidence of those stresses in the form of folds, faults, and rock crushing. In places the strain resulted in folds—here open, there sharply bent. In other places the strata broke instead of bending, and sharply defined faults resulted. A more frequently noted evidence of rock stress, however, is slickensiding of the harder strata or crushing along bedding planes in the softer zones, owing to constantly recurring slippage along lines of least resistance. Crushing is most common in the coal beds, the result being ordinarily either a finely crushed, almost incoherent mass or flakes having the appearance of molybdenite. Flat-lying beds are rare; instead, steep dips prevail. Overturned strata are not uncommon. In fact, the more closely the field is studied the more one appreciates what tremendous forces have been at work to deform from their original recumbent attitude the formations involved.

From the foregoing general statements it will be gathered that the writer views the Bering River coal field as an area of great structural complexity, and no one knowing the significance of geological evidence can arrive at any other conclusion. The complete history of the deformation, however, can not be given here, for the lack of any readily recognized rock stratum and the prevailing absence of natural exposures combine to render a complete interpretation of structural forms a tedious if not impossible task. Moreover, regional study is quite as necessary as local observation in deciphering the history in its completeness, and for such study time was not available, nor was it considered pertinent to the particular problem involved in the investigation. Martin in his publication on the field gives an excellent discussion of the structure, though even his extended investigation was not sufficient for unraveling entirely the tangled evidence obtained. According to Martin—who in this view is entirely in accord with that of the writer—the theory best accounting for the structural conditions as known is based on the following suppositions:

(1) That there was, in late Tertiary time, a zone of intense deformation in the present position of the Chugach Mountains, but that this deformation did not extend into the coastal part of the region here described.

(2) That the rocks now outcropping on the shore of Controller Bay were then well to the north of their present position and were involved in these intense movements.

(3) That, as a final stage in their deformation, the Tertiary rocks rode southward in one or more great overthrusts and came to rest on Mesozoic strata, which were at a distance from the zone of intense deformation and hence were not affected by it.

It does not seem essential, however, in this report to state the various lines of evidence upon which Martin bases his theory, as results rather than causes of deformation are of prime importance in the present consideration of the economic aspect of the Bering River field. The general structure of the area involved is a steeply dipping rock succession, the prevailing direction of the dip being to the northwest. Locally, this direction may be altered markedly by faults or transverse folds. Four large faults are known to traverse the coal field, as shown on the accompanying map (No. 1.) Kushtaka Ridge is cut by two of these, one near the southern end and another along the western slope. The other two faults outline a narrow block east and south of Charlotte Lake. There are several other displacements of considerable magnitude in the mountainous district near the coast, but these have no special bearing on the economic value of the field. Throughout the entire area, however, faults of lesser dimensions are exceedingly numerous, some representing a stratigraphic displacement of several hundred feet.

Every tunnel of any consequence encounters one or more of these lesser breaks. In the northeastern part of the field the Davis mine has struck at least six of these faults in 500 feet of entry. The McDonald mine at the opposite end of the field near Bering Lake discloses similar conditions, and the prospect tunnels in the intervening area encountered the same difficulty. Such faults are particularly objectionable in the Bering River field, for in addition to presenting the customary trouble in driving they act as underground channels for the excessive amount of water that permeates every part of the rock section.

Dozens of faults of sufficient magnitude to be noted without special search were observed in the general surface examination of the field, but their very number prevented detailed recording. Just below the falls on the middle fork of Barrett Creek a strike fault was noted that must be of considerable displacement, as it appears to cut practically the entire middle group of coals. A less apparent fault, but one that was demonstrated beyond question in the course of prospecting, trends up the valley of Trout Creek near the center of the Tenino claim of the Cunningham group. The presence of this fault was not suspected till attempt was made to find the eastward extension of the coals exposed along the west bank of the creek. The continuation of the hard 30-foot bed was made an especial object for search, but it certainly is not to be found at its supposed location as indicated by the strike shown at the tunnel. Moreover, at certain localities on the east bank, where trail making has exposed the rocks to view, the dip is changed from its expected high angle, becoming almost flat. In all the prospecting done previous to the present investigation and in the later detailed search made under the supervision of Mr. Calvert it is significant that not one of the larger beds opened on the west side of the valley has been found on the east bank.

The middle course of Bear Creek near point 64, map No. 1, shows along its canyon walls much structural disturbance, usually in the form of faults. In fact, it may be stated that every part of the field, except possibly the ridge lying between Trout Creek and Kushtaka Glacier, is traversed by an intricate system of fault lines, making underground development everywhere tedious and costly and in many places almost, if not quite, impracticable, except where the extraction of only a limited amount of coal is contemplated.

Folds are frequently associated with the structure of the Bering River field. They appear to increase in number progressively northeastward, the Carbon Mountain anthracite district being especially involved in this type of structure. In this northeastern part of the area the folds are much compressed and some are overturned in addition, but to the southwest some of the folds become more open. The majority of the folds are along or only slightly divergent from the normal northeast strike, though there are several notable exceptions to this general rule. Carbon Creek in the western part of the field is cut along the axis of such an abnormal anticline.

In view of the many folds exposed here and there by the erosive action of streams, it is reasonable to assume that many others are present, for the reason that as the stream cutting is purely accidental it would be unlikely to uncover only those areas where folds exist. Because of the large number of folds known to be present in the field, it is not always safe to assume, in passing over a seemingly normal rock succession, that conditions are as they seem, for localities have been noted where a single coal bed appears at the surface as three nearly parallel lines of outcrop. Such examples were observed in the Carbon Mountain district, at the head of Moores Creek, and on Carbon Creek.

The writer is firmly convinced that there is a close relationship between the structure of the Bering River field and the physical character of the coal. It has been stated previously that the coals below the anthracite class are prevailingly soft, and with a molybdenitic appearance. Occasionally, however, an exposure was noted where the coal is hard and lacks the usual crushed look. A careful study of this anomalous condition demonstrated that the physical hardness resulted from close association with folds or large faults. During the period of overthrust, when the entire rock mass moved seaward, there were successive shear movements along bedding planes, and where such movements were not checked the coal beds were crushed excessively. Locally, however, the rock section broke sharply, and became arched or depressed into folds, thus relieving from shearing action rocks adjacent to such fault planes or involved in the folds themselves.

Along major faults, therefore, or in compressed folds the coal, when present, though slickensided, is usually not foliated. The extensive folding in the Carbon Mountain district is believed to have been a prominent factor in the formation of the hard coal such as is known to exist there. The two beds of hard coal opened on the west bank of Trout Creek are now known to be adjacent to a large fault. On the east slope of Kushtaka Ridge a 6-foot bed of hard coal outcrops very near the major fault, trending from the south end of the ridge to the north end of Kushtaka Lake. On Queen Creek a bed of hard coal is exposed on either limb of a closely compressed fold. Again, at the head of the south fork of Barrett Creek a closely folded anticline involves a small coal bed, and there also the coal is hard. In fact, nowhere in the field does it appear that hardness of coal is not immediately associated with abnormal structure. Hence, development on a hard bed is very likely either to encounter a fold or fault in one direction, or in the opposite direction to yield progressively softer coal as the distance from the abnormal structural condition increases.

THE COAL.

AREAL EXTENT.

As the Kushtaka is the principal coal-bearing formation of the Bering River field the surface extent of the important coals is restricted to the area of outcrop of that formation, which is shown on the map accompanying this report. Coal outcrops have been found in what is believed to be the upper part of the underlying Stillwater formation, but little information is available concerning the extent and character of these coals. It is believed that they are commercially unimportant. The total area underlain by coals of the different varieties in the Bering River field has been estimated by Martin to be 68.4 square miles, including the outcrop area of the Kushtaka and the area to the northwest to a depth of practical mining.

STRATIGRAPHIC POSITION.

The coals are distributed throughout the entire thickness of the Kushtaka, and possibly into the upper part of the underlying Stillwater formations. It is believed that more than 20 beds of locally workable coal occur within the Kushtaka, but owing to the prevailing complexity of structure that exists in this field it is possible that some of the beds believed to be distinct are in reality duplications. These beds arrange themselves into three rather indefinite groups—a lower, a middle, and an upper.

The evidence favoring the belief that these groups are distinct within themselves and not duplications caused by major strike faulting consists in the wide variation in stratigraphic interval between individual beds in the respective groups, especially when the lower is compared with the middle or the upper; also in the difference in the aggregate number of coal beds present in each group, even when these groups are examined at nearby places across the strike, as on Barrett Creek, and further in the absence of indications of disturbance of strata such as should be present if strike faulting sufficient to cause group duplication had taken place.

The lower group contains eight beds of coal which are moderately thick and generally 100 to 800 feet apart; the middle group has nine beds closely grouped within about 400 feet of strata, and the upper group contains five beds of variable dimensions and slightly more widely separated than those of the middle group.

THICKNESS AND CHARACTER.

The various beds of coal found in the field range in thickness from 6 to 10 feet. The thickness of the individual beds varies considerably. In some places there is an actual thinning of the entire bed, and at others impure coaly shale or horsebacks reduce the thickness of the pure coal.

In physical properties the coals of the Bering River field bear a strong regional resemblance to each other. They are prevailingly soft and friable, with a pronounced foliated structure and graphitic luster. In at least 90 per cent of the beds the coal has been badly crushed and shearing planes are highly developed. A few beds appear to be moderately firm, but such beds are generally closely associated with faulting, where the pressure causing deformation has been released. The soft, friable condition of the coal is not a surface aspect due to weathering, as has generally been supposed, but is deep seated. In different parts of the field where development work has been carried on, the coals that are soft and friable at the surface do not increase preceptibly in hardness under ground.

According to analyses made from samples collected by Martin, Holmes, and Storrs, the coals of this field grade from semibituminous to semianthracite, but, as the change in these coals from one class to another is transitional, it is impossible to draw a sharp line of demarcation between them. In general, the west half of the field is underlain by semibituminous and the east half by semianthracite coal. Considering the entire district the coals range in amount of fixed carbon from 73 per cent to 87 per cent, in volatile matter from 7 to 18 per cent, have a low moisture content, and are low in ash. In calorific value they range upward from 14,000 B. t. u.

Following is a table of analyses showing various samples of Bering River coal that possess the proper chemical qualities for a desirable naval fuel:

Analysis of Bering River coals.

[Samples yielding from 12 per cent to 22 per cent volatile matter and more than 14,000 B. t. u.]

Sample No.	Laboratory No.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	B. t. u.	Reference.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*		
12	12715	1.60	11.90	84.70	1.80	0.95	15,020	Holmes.
4	12708	1.80	14.00	81.70	2.50	1.15	14,860	Do.
13	12717	1.80	13.70	79.90	4.60	1.20	14,400	Do.
10	12706	2.90	12.10	80.30	4.70	1.20	14,080	Do.
8	12712	2.10	13.50	78.20	6.20	.70	14,180	Do.
A	....	2.12	13.00	82.18	2.70	None.	....	Storrs.
B	....	2.72	12.34	80.44	4.50	.15	....	Do.
C	....	4.34	14.08	73.38	8.20	.50	....	Do.
D	....	3.10	13.24	81.26	2.40	.01	....	Do.
E	....	3.34	12.34	82.82	1.50	.40	....	Do.
F	....	1.62	14.37	77.21	6.80	.88	....	Do.
G	....	1.92	15.29	77.29	5.50	.26	....	Do.
H	....	2.65	13.93	74.12	9.30	None.	....	Do.
I	....	2.02	13.41	81.22	3.35	None.	....	Do.
J	....	2.17	12.45	81.58	5.80	None.	....	Do.
K	....	1.32	14.10	81.98	2.60	.28	....	Do.
L	....	1.70	13.07	79.93	5.30	None.	....	Do.
M	....	.76	13.76	81.03	4.45	Trace.	....	Do.
N	....	2.20	14.15	81.90	1.35	None.	....	Do.
O	....	1.34	14.14	75.02	9.50	Trace.	....	Do.
P	....	.86	13.50	80.89	4.75	Trace.	....	Do.
Q	....	1.38	13.52	82.55	2.55	None.	....	Do.
R	....	1.98	14.80	81.02	2.20	Trace.	....	Do.
S	....	1.54	12.66	83.00	2.80	.77	....	Do.
T	....	2.11	16.58	79.68	1.63	.78	15,574	U.S.G.S. Bull. 335.
U	....	2.36	18.12	71.87	7.65	.73	14,074	Do.
V	....	5.43	13.12	79.65	1.80	.67	14,445	Do.
W	....	4.23	14.03	79.75	1.99	.96	....	Do.
X	....	.56	16.61	78.71	4.12	1.25	....	Do.
Y	....	5.66	13.65	76.81	3.88	.77	14,558	Do.
Z	....	1.20	17.28	77.69	3.83	.78	....	Do.
AA	....	4.94	13.34	77.29	4.43	.83	....	Do.
BB	....	4.01	12.46	77.47	6.06	1.11	14,171	Do.
CC	....	4.22	13.37	78.80	3.61	1.56	14,398	Do.
DD	....	.38	16.97	77.48	5.17	1.02	....	Do.
EE	....	5.95	13.01	76.12	4.92	.61	....	Do.
FF	....	2.41	15.03	79.24	3.32	.51	15,021	Do.
GG	....	6.03	12.98	78.40	2.59	.70	14,332	Do.
HH	....	5.14	13.90	75.96	5.00	1.16	14,065	Do.

ATTITUDE OF COAL BEDS.

Most of the coal beds dip steeply, the dips ranging from 46° to 50° to the northwest, with strike to the northeast. However, owing to the faulted and disturbed condition of the measures the dip and the strike of the coal beds deviate widely from the normal in many places. In certain localities the direction of the dip and the strike of the coal bed are directly reversed, and in other places several changes in the direction of dip and strike take place within a very limited area. The absence of adequate exposures in places of this kind made it practically impossible to determine the local structure so as to predict with any degree of certainty the position of the coal bed involved.

COMBUSTION.

The coals of the Bering River field being high grade burn with a short flame and emit little smoke. Throughout the western part of the field, or the coking-coal area, the coal fuses somewhat and cakes soon after ignition; consequently, it "bridges over" in the fire box and prevents compactness of the fuel mass, thus tending to smother combustion, a tendency that must be regarded as having a certain redeeming value in such a friable coal.

Previous workers in this field have subjected the semibituminous coals to improvised coking tests with results, in the main, satisfactory. The samples tested generally yielded a bright, silvery, finely porous coke, which was rather light but firm. It is probable that under proper treatment nearly all of the semibituminous coals of this field can be made to yield an average quality of coke.

DESCRIPTION BY DISTRICTS.

CLEAR CREEK DRAINAGE BASIN.

DETAILED DESCRIPTION.

On the date of our arrival in the field, August 24, an examination was made of the lower course of Clear Creek in the vicinity of Cunningham Cabin. On the following day, August 25, we followed up Clear Creek to near the mouth of Barrett Creek, where one thick coal bed, opening in two places and occurring in the so-called lower group of coals in this field, was examined. The bed was about 12 feet thick, and dipped at an angle of about 35° to the northwest. It was composed of bright looking coal, which was badly crushed and sheared, causing a molybdenitic structure. It contained about 5 per cent of hard, coaly, cannon-ball nodules, which were obviously very impure and which in burning would yield a large percentage of ash. We continued up Clear Creek to the mouth of Barrett Creek, where we followed the trail on the left side of the stream to a point above the falls, the coals showing in Barrett Creek having been previously examined by Fisher, who determined their character and thickness. After reaching a point above the falls on the east bluff of Barrett Creek, we descended into the Creek Valley and followed up a short, narrow, canyon tributary on which are exposed about 12 beds of coal 4 to 12 feet thick, in close stratigraphic proximity and constituting the so-called middle group of coals of this geologic section. These coals are bright and relatively clean, but, without exception, badly crushed into a molybdenitic structure. Shaly bodies, commonly known as "horsebacks," are frequent in the thicker beds, and the entire series dips at an angle of about 45° to the northwest.

After reaching the head of this canyon, where the higher coal horizons are concealed by moss and tundra, we followed along the strike of the formation to the north fork of Barrett Creek, thence down that canyon tributary to Clear Creek, again passing through the middle group of coals at another point on the strike. Here the general series of coals seen on the south fork of Barrett Creek could be recognized; that is, a number of coal beds occurred in close proximity and at the same stratigraphic position with respect to the Kushtaka, so that the groups seen on the north fork of Barrett Creek could with certainty be correlated with those on the south fork but the individual beds are changed so much in character as to render their correlation doubtful.

The coals of the lower group exposed in the vicinity of the mouth of Barrett Creek are easily accessible, occurring at an elevation of 500 to 600 feet above sea level, whereas the middle group of coals, comprising many more beds, ranges from 1,200 to 1,600 feet above sea level, or 1,000 feet above Clear Creek, and is consequently much more inaccessible.

On August 26 an examination was made of the area drained by the headwaters of Clear Creek. About 200 feet west of the so-called Storrs Cabin, at the base of the falls on Clear Creek, the face of a bed of coal 12 feet thick had been cleaned; the bed had also been opened by a short tunnel lower on the dip. The coal in this bed is bright and clean, but contains the cannon-ball nodules mentioned above. The bed is crushed and sheared throughout. It occurs immediately beneath a bed of coarse arkose or sandstone, and because of its stratigraphic position near the top of the lower group of coals, it should probably be correlated with one of the coal beds just beneath the falls on the south fork of Barrett Creek. As stated above, a 12-foot tunnel had been driven in this bed beneath the heavy sandstone. The coal at the end of this tunnel is as soft and crushed as that at the surface.

From this opening the party followed up Clear Creek to above the falls, thence up a small tributary from the west where a tunnel 70 feet long had been driven on the south bank of the creek on a 1½-foot bed of coal, which was badly broken and faulted. The dip of the bed is 40° to the northwest, and the bed is clearly of no value. A short distance from this tunnel there is a bed of coal over 40 feet thick, without partings, exposed on the top and east facing bluff. This coal is soft and crushed throughout and a short distance to the south the bed is perceptibly thinned by a shaly parting. The party did not examine this thick bed, as it had been previously examined by Fisher, who determined its lenticular character.

From the tunnel mentioned we proceeded up a branch of Clear Creek coming in from the northeast past Chezum Cabin to the top of Canyon Creek ridge, thence along the crest of the ridge, where several beds of soft, crushed coal of workable thickness were examined. The soft character of the coals and the inaccessibility of the outcrops render the coals of little value.

From the top of Canyon Creek ridge a study of the broader structural features of the Canyon Creek district was made. In upper

Canyon Creek the coal-bearing beds are badly faulted and broken, so that they are probably of little value as a source of fuel. From Canyon Creek ridge we followed down one of the tributaries of Clear Creek, entering from the northeast, to Clear Creek and returned to Cunningham Cabin.

On the next day, August 27, we followed up Clear Creek to the mouth of Moore Creek, thence up that stream. A short distance above the mouth a poorly-exposed bed of coal was seen which may correlate with the 12-foot bed on Clear Creek. A few hundred feet farther up Moore Creek a 3-foot bed of clean coal was seen crossing the stream and dipping at a high angle. Near the base of the falls we examined three coal beds dipping at angles of 45° to 56° to the northwest, two of which are of workable thickness, but show the characteristic crushed and sheared condition notwithstanding their stratigraphic position, which was immediately beneath a massive sandstone over 300 feet thick. This and many other localities demonstrate that the character of the overlying rock has no bearing on the physical character of the coal.

From here we proceeded up a narrow canyon to the head of Moore Creek and on to the saddle on Cunningham ridge, through which the trail passes. Here two heavy beds of soft, crushed coal had been partly opened up, but the exact thickness could not be measured. The uppermost of these beds has a thickness of about 12 feet, and the other, about 60 feet lower, is approximately 30 feet thick. Below these two beds, which are believed to belong to the basal portion of the upper series, are a number of thinner beds, poorly exposed, on the head of Bear Creek. We followed down this stream past the falls where a bed about 12 feet thick was examined. The coal is bright and clean in appearance, but very soft and friable. Continuing down this stream to its mouth we proceeded up Trout Creek to the cabin, where a new camp was established and preparation made for a detailed examination of all the beds and tunnels in the vicinity of Trout Creek Cabin where considerable prospecting has been done.

SUMMARY.

All of the coals of the Kushtaka formation outcrop within the district covered by the Clear Creek drainage basin. The lowest group outcrops on Clear Creek and below the falls on Barrett and Moore Creeks; the middle group above the falls on Barrett and Moore Creeks, on the extreme headwaters of Clear Creek, and on the crest of the divide between Clear and Canyon Creeks; and the upper group along the southeast face of Cunningham Ridge, near the top.

The coals of the lower group are the most accessible of any in this district. On the lower courses of Moore and Barrett Creeks, and along Clear Creek between the two, there are beds of considerable thickness which could be easily reached, but they dip steeply, so that the greater part of their coal tonnage is below water level. In the district also strike faulting is known to exist in at least two places, opposite the mouth of Barrett Creek and a short distance below the stream.

In quality the coals of this locality possess the naval requirements of volatile content and heat value, but are relatively high in ash. They are badly crushed and sheared and would yield a very large percentage of slack upon mining. About three-fourths of a mile farther up Clear Creek and below the falls several beds of coal outcrop, presumably belonging to the same group, which showed some of the best analyses of any coal in the district; the position of the beds in the hills also insures a large tonnage of coal above water level. The coals of these beds, however, are all badly crushed and sheared, and in the immediate vicinity is reported a sill of igneous rock, the extent of which is unknown. About 300 feet above the stream bed on the west side is a 45-foot bed of coal which contains benches of excellent coal, but the bed is soft and crushed throughout and its thickness is not believed to be continuous. Less than 100 feet to the south of the 45-foot opening the bed decreases in thickness to 25 feet by the development of shaly members.

The coals of the lower group outcropping on Canyon Creek ridge are all soft and crushed, their outcrops are in inaccessible places, and objectionable faulting is prevalent in the district. Therefore they can not be regarded as worthy of consideration in the present investigation.

The middle group of coals that outcrop on the head of Moore Creek and on the north and south forks of Barrett Creek, also in the southwest face of Cheezum Ridge, are all relatively inaccessible, although they could possibly be reached by a water-level tunnel from Clear Creek. In the above localities the middle group contains thick beds of coal which meet the chemical requirements of the Navy, but the coal is prevailingly soft, crushed, and sheared, and most of the thicker beds contain horsebacks of slickensided bodies of shale which locally render the bed unworkable.

The same objections as to physical character of coal and condition of beds is applicable to the upper group on the southeast side of Cunningham Ridge. These coals are even more inaccessible than the middle group. In view of the above, the coals found throughout the drainage basin of Clear Creek were regarded as unpromising for naval purposes, the most important objections being the soft, crushed condition of the coal, the percentage of impurities in the thicker beds, the faulted and disturbed condition of the coal beds or the rocks in the district in which they are found, and the inaccessibility of the coal beds for mining.

TROUT CREEK DRAINAGE BASIN.

DETAILED DESCRIPTION.

On August 28 the party made a preliminary examination of all coal beds and prospects on Trout Creek. This district, even in advance of the preliminary investigation, was generally regarded as likely to prove worthy of more detailed prospecting, a belief based on previous work of the writer and of Mr. S. S. Smith, supplemented by the conclusions of previous investigations and the results of considerable development work representing private capital.

The work was begun at an outcrop of coal partly opened up, about 300 feet north of the cabin. The exposure was in the point of a ridge 50 feet above the bed of Trout Creek. While this coal bed was of workable dimensions, it was badly crushed and sheared. About 200 feet farther north, on the same side of the creek, there was a tunnel, probably on the same bed, 100 feet long. The bed here had a workable thickness at the entrance, but thinned to 18 inches at the face; and exhibited soft, crushed coal at both the mouth and face of the tunnel. No gas was found in the tunnel in the preliminary examination.

From this tunnel we continued up Trout Creek to the waterfalls, where several small beds of coal were poorly exposed in a rather inaccessible gorge. Here the dip of the rocks was steep (50°) and the strike northeast. We returned to the cabin along the west side of Trout Creek, stopping for a brief examination of a tunnel about 200 feet up the slope of the hill. This tunnel, which is 175 feet long, had been driven on a coal bed 5 feet thick at the mouth of the tunnel, but decreasing to 3 feet at the face, and exhibited coal mainly soft, but containing one hard 10-inch band near the top. The characteristics of the bed at the face of the tunnel, where it was under 150 to 200 feet of cover, did not change. No gas was observed in the tunnel at this time.

From here we followed along the west bluff of Trout Creek to the two tunnels opposite Trout Creek Cabin, which were both examined in detail underground. A connection was found between the two, and it was further observed that they had been driven on separate coal beds, the upper one of which was 8 feet thick at the opening. The coal in the lower bed, which appeared to be thicker, was crushed and disturbed, whereas the upper or thinner bed was moderately hard and bright looking at the entrance. It was decided to prospect this 8-foot bed further when the miners arrived, but the thicker bed was obviously too badly crushed and sheared, and the rocks too broken to warrant more extensive prospecting. From these tunnels the outcrop of the two beds was examined in natural exposures for some distance up the hill to the southwest, where more detailed prospecting was done later.

The next locality to be examined by the party was the so-called "30-foot bed" on the west side of Trout Creek, where the most extensive underground prospecting in this part of the field had been done. Here a detailed examination was made of the underground workings and preliminary measurements were made of the coal beds both underground and at the surface. The exceptionally hard and firm character of the coal for a field of this kind was noted and a few hand specimens collected. From this cursory examination it was decided that the bed warranted more surface and underground prospecting in order to ascertain the probable area underlain by a bed of this thickness. The attitude of the bed appeared to be favorable for mining, and the hardness of the coal, judging from the appearance of the ribs and face of the tunnel, warranted the belief that a larger percentage of lump could be obtained from this mine than from any bed previously examined. The quality of the coal was then regarded as of possible desirability for naval use. The result of more detailed prospecting on this bed, both on the surface and underground, is given in the following report by Mr. Williams on the mining conditions in the field.

Continuing downstream below the opening on the 30-foot bed we saw two tunnels opened on beds that were not promising. Returning to the cabin on the east side of Trout Creek, we made a rather doubtful correlation of a 30-foot bed with a coal bed located on the east side of Trout Creek. However, later detailed prospecting by Mr. Calvert proved that this correlation was incorrect, also that a fault in Trout

Creek Valley at this place rendered it very difficult, if not impossible, to correlate with certainty the coal beds across this stream. We also examined another short tunnel opened on a workable bed of soft, crushed coal. As a result of extensive surface prospecting by Mr. Calvert, assisted by several miners, a bed about 500 feet south of the 30-foot opening was selected as a satisfactory bed from which to take the larger sample. This selected bed was later found to decrease in thickness to a few inches, in a short distance. The taking of the large sample from this place was therefore impracticable. Detailed information concerning later development on the west side of Trout Creek is given in a following chapter of this report by Mr. Williams.

On August 29, we moved camp down Trout Creek to the Kushtaka trail and thence over to the lake where we crossed to the rock tunnel on the English company's land. Here a tunnel had been driven about 400 feet, cross-cutting strata that dipped at a steep angle to the northwest and stopping at a fault. Only one thin coal bed, located near the fault, was penetrated by this tunnel. A previous worker in the field reports a bed of coal near the mouth of the tunnel, but a careful search by our party failed to locate it.

From the rock tunnel we followed up the English company's trail to the top of Kushtaka Ridge. About half way up the mountain we examined a short tunnel on a 4-foot bed of soft, crushed coal which, as shown by analysis possesses the requisite volatile matter and a heating value of nearly 14,500 B. t. u., but its position on the hill rendered it very inaccessible from this point. This tunnel, if continued, would probably encounter within a short distance a large strike fault, the location of which is shown on the geologic map.

From here we continued up the hill and, after reaching the top of the first shelf, followed up a short canyon past a 14-foot bed of coal, of which the upper 4 feet was moderately hard, but the lower 10 feet soft and crushed. This bed was on the north limb of a sharp syncline with a corresponding closely folded anticline on the north. This zone of close folding and faulting extends southwest across Kushtaka Ridge into the head of the area drained by Carbon Creek. While the party was climbing to the top of Kushtaka Ridge, several coal openings were found in this disturbed zone. The coal beds seen are generally soft and crushed and the coal measures too badly broken to be considered of importance in the present investigation.

From the top of the Kushtaka Ridge we proceeded down a tributary of Carbon Creek, known as Queen's Creek, to the exposure of a bed of hard, bright-looking coal about 30 feet thick, which was in a closely folded and faulted zone. The extent of this bed is, however, too local to render the bed of value. Hand specimens were collected for the purpose of study, as it exhibited remarkable pressure phenomena. This coal, both in physical properties and chemical composition, would meet naval requirements, but the bed, owing to close folding and erosion, is of too limited extent to warrant mining. From this exposure the party followed down Carbon Creek to the English company's home camp in the edge of the Shepherd Creek Valley.

On August 30 an examination was made of the underground development of the coals in the vicinity of the English company's home camp. One locality visited is situated about 300 yards southeast of the home camp on the east side of a small tributary of Carbon

Creek, indicated on the geologic map No. 1 as No. 64. Here a bed of coal about 19 feet thick and standing nearly vertical had been entered in the footwall by a tunnel 60 feet long, with crosscut through the seam at the face. The coal here was clean and bright, and analyses showed an ash and a volatile-matter content in keeping with naval requirements, and a thermal value of over 14,000 B. t. u. It was soft and friable, exhibiting the characteristic molybdenitic structure of this field. The bed was near a fault with displacement of several hundred feet. The direction of the strike of this bed indicates that it is cut off in one direction at least by the fault within a few hundred yards of the opening.

The next tunnel to be examined was about one-quarter of a mile up Carbon Creek from the cabin on the north side of the creek, where a rock tunnel, crosscutting the beds for a distance of 300 feet, had been driven without penetrating a single coal bed of workable dimensions, one small band being the only coal found. It is believed that this tunnel was intended to penetrate a workable coal bed that is exposed a short distance farther up the creek on either side of the valley. However, a closely-folded anticline, followed by the stream, pitches beneath the stream bed above the point where the tunnel enters the hill. As the local geologic structure had not been understood, the tunnel had been started in the wrong place; that is, too far down the creek and stratigraphically above instead of below the coal bed showing upstream, and consequently the tunnel did not cut it. Considerable water was found in the tunnel, although the structure of the rocks penetrated was unusually regular for this field. The dip of the beds in the tunnel was 60° to 70°. About one-eighth of a mile up Carbon Creek the coal bed is exposed, and appears to be of good quality. Nearly opposite, but slightly upstream from this exposure, a bed of coal believed to be the same, but outcropping on the other limb of the fold, was observed. A tunnel had been driven on it. This bed was examined both at the surface and underground, and the main tunnel was found to be 30 feet long, with one side entry extending about 30 feet. The coal is moderately firm, and appears to be relatively free from impurities, although no analysis of this coal was available. The tunnel was located near a large fault which cuts off the coal measures a short distance away.

We next proceeded up the trail toward the English company's upper cabin and along the line of a large fault which exhibited disturbed structure wherever exposures occurred. At a point marked 60 on the geologic map No. 1 a tunnel 250 feet long, which followed the strike of a 7-foot vertical bed of coal, was observed. The coal was moderately hard, probably owing to its nearness to the fault, and was seemingly of good quality, but was too near the disturbed zone of faulting to warrant further investigation.

From this tunnel the party followed up the trail past the English company's upper cabin near Kushtaka Ridge and down to the English company's cabin on Canoe Landing. About 1,000 feet above this cabin, on the east face of Kushtaka Ridge and at one side of the trail, a short tunnel had entered on the lower 6 feet of a coal bed of considerable thickness, but soft and impure in the upper part. The lower 6 feet of this coal bed was relatively hard, bright, and clean, and on analysis showed the requisite properties for naval use. Although the coal bed at this opening was not readily accessible, being

1,000 feet above the lake, the gradient between the opening and the lake is so steep that a gravity tramway could be installed for lowering the coal to the lake shore. This coal bed may be the same as the one examined 800 feet above the rock tunnel, but lack of exposures between the two openings make such correlation uncertain. After examining the opening the party recrossed Kushtaka Lake and returned to Green Cabin.

From a general reconnoissance of the English company's lands, therefore, it appeared that there are two localities where it seemed advisable that further prospecting be done to determine the regularity of the coal-bearing measures and the continuity and prevalent character of the coal beds contained therein. One of these areas, where it is possible that there is an undisturbed body of coal sufficiently large to warrant mining, is on the east side of Kushtaka Ridge above the cabin and the rock tunnel. This area lies in a fault block one-half to three-fourths of a mile wide, but if further exploitation demonstrates that no minor disturbances exist in this fault block, and the bed examined at No. 48 (see map No. 1) maintains a uniform thickness over this area, a considerable tonnage of coal could be taken out. The other area where more extensive prospecting might be justified lies on the northwest side of Carbon Creek under Carbon Creek ridge, which, for the most part, is composed of the Kushtaka, the principal coal-bearing formation, but is capped by the Tokun formation, which does not bear coal. This ridge appears to be free from major faulting, and as its southeast face is composed of the upper half of the Kushtaka formation, coal beds should be present in this bluff. If the face of this ridge, after further prospecting, should be found free from structural disturbance, and the beds to be uniform, a body of coal land 1 square mile in extent might be found in this ridge. The coal examined in the valleys of Carbon Creek and its tributaries, Ocean and Leeper Creeks, are in a zone of too complex structure to warrant development on a large scale.

CANYON CREEK DRAINAGE BASIN.

On August 31 we proceeded from Green Cabin at the mouth of Stillwater Creek up Canyon Creek to Hunt Cabin, examining local folding of the strata and faulting on either side. From the cabin we followed up a small canyon to the east, a distance of about one-eighth of a mile, where the principal development of the coals of this area has taken place. Here much machinery had been installed and a tunnel driven a distance of about 400 feet under several hundred feet of cover. The bed opened has a total thickness of 11 feet and dips at a high angle. Only the upper 3 to 4 feet is sufficiently clean to be considered. This coal was soft and friable, and at the surface the bed is unpromising in appearance. In examining the tunnel six different places were noted where minor faulting had shifted the bed out of position or caused it to thin materially. In the judgment of the engineers of the party this bed, from surface indications alone, did not justify the amount of money that had been spent in its exploitation. About 1½ miles east of this locality, on the southeastern slope of Carbon Mountain, there are a number of coal prospects which were not examined at this time owing to the fact that they had been previously examined by Mr. Smith, a member of the party, and were known to exhibit soft, crushed coal, highly inaccessible and of a quality not suited for steaming purposes; that is, having a volatile matter content considerably lower than 12 per cent, which places them in the anthracite variety.

On the whole, the coals of the Canyon Creek basin were regarded by our party as unpromising as a source of naval coal because, as stated above, they are too near the anthracite variety to be desirable for steaming purposes, and the structure of the coal-bearing measures is too badly broken to justify the hope of finding a large body of undisturbed coal.

THE M'DONALD AREA.

September 1 our party went down Bering River by motor boat to the mouth of Bering Lake, thence across that lake to the McDonald home camp, where we examined the so-called McDonald mine. This mine was formerly well equipped for taking out coal, and a tunnel had been driven into the hill at a point about 300 feet above the lake on a 6-foot bed of impure coal. Several minor faults in this tunnel materially damaged the coal bed. After thoroughly examining both the surface and the underground conditions of this mine, it was the consensus of opinion that this bed should not have been opened, for with the most favorable equipment it is very doubtful whether coal in considerable amounts could ever be mined at this place from the present opening. The percentage of slack from this mine was very large, probably over 90 per cent of the entire output. An opportunity was here afforded for the examination of the behavior of this coal in the furnace, and samples were collected from the fire box. It was observed that the coal, when beginning to burn, fused and caked, "bridging over" in such a manner as to prevent the fuel from packing down and smothering combustion. We were informed by the engineer who had been burning this coal that if special precaution was taken to feed the fire box slowly at first, allowing time for the "bridging over," little difficulty was experienced thereafter in using the slack coal under stationary boilers.

Two other small openings had been made in coal beds a short distance south of the McDonald mine. These openings did not extend more than 30 feet into the coal bed, which in both localities is soft and crushed and is about 4 feet thick. Coals adjacent to the McDonald camp are of a quality suitable for naval purposes, but the beds examined are either too thin or too badly disturbed to warrant further development. On top of the ridge a short distance south of Mount Hamilton some coal openings have been made which were not examined in the party's reconnaissance, as they were regarded too inaccessible for practical purposes. At Poul Point a thin bed of coal had been opened by a short tunnel, but had proved to be below minable thickness.

DETAILED PROSPECTING ON TROUT CREEK.

(Map No. 2.)

As stated in a previous chapter of this report, the object of the general examination of the entire Bering River field by Messrs. Fisher, Calvert, Williams, and Smith immediately after their arrival at Katalla and preceding the arrival of the mining force from Seattle was to ascertain the most desirable locality or localities from which to take one or more large samples of representative coal for a practical Navy test. In this general examination every essential factor was taken into consideration, such as quantity and quality of coal and accessibility. The Tenino claim of the Cunningham group was finally selected. This claim is traversed from north to south by Trout Creek, thus affording easy access to the coal, as there is a readily available passageway to and from tidewater. Moreover, there appeared to be at this locality the greatest quantity of available coal of the physical and chemical character required for Navy use. Opposite the Cunningham Cabin on Trout Creek an 8-foot bed of hard coal had been opened, and about 850 feet farther downstream a 30-foot bed of similar coal had likewise been developed by a prospect entry. Nowhere else in the field could beds of such thickness combined with the desired physical character be found. At that time it was not known that the desire of the Navy Department was to obtain representative rather than exceptionally hard coal.

The locality mentioned having been selected, it next became incumbent to ascertain by surface prospecting what underground conditions would be likely to be encountered in actual development. Accordingly the respective lines of outcrop of the two beds on the west side of Trout Creek were carefully traced by means of closely placed prospect pits. This work was done under the supervision of Mr. Calvert, first with the aid of local residents employed for the task, and later, upon the arrival of the mining force from Seattle, by an addition of such men as were immediately available. It was soon ascertained that the 8-foot bed west of Trout Creek could not be regarded as of prospective value, for within 600 feet of the original prospect entry it decreased to 16 inches. In addition the coal was dirty. Attention was then directed to the 30-foot bed which was stratigraphically lower. Some difficulty was experienced in tracing the line of outcrop to the southwest, as a thick mantle of talus and tundra effectually conceals the underlying rocks in that part of the field except for very rare exposures. The bed was uncovered, however, several hundred feet southwest of the nearest exposure by digging a trench some 60 feet long and 10 feet deep. Here the coal was shown to decrease to 18 feet and to be materially changed in character, resembling the usual soft coal of the field. At a point still farther to the southwest, probably about 1,000 feet from the original prospect tunnel, the bed was found to lessen to 4 feet of soft, dirty coal.

It having thus been demonstrated that the two beds in question are lenticular west of Trout Creek, endeavor was made to find the extension of those beds to the east. Trenching back of the cabin failed to disclose the 8-foot bed at its expected location, and a similar failure resulted in regard to the eastward continuation of the 30-foot bed. A coal bed outcrops on a ridge opposite the tunnel opening on the 30-foot bed, and at first it was considered to be the eastward extension. When opened, however, it was found to be only a 3-foot bed, faulted and badly crushed. A 32-foot bed had been reported by Storrs as outcropping on the south bank of the west-flowing stream entering Trout Creek about 500 feet below the prospect tunnel on the hard, 30-foot bed. When it had been ascertained that the 30-foot bed does not occur at its expected location on the east side, the coal mentioned by Storrs was assumed to represent the true eastward extension, faulting having offset the outcrop to the extent indicated. This exposure was carefully faced up after considerable labor, and it was found that only 6 feet of soft, slickensided coal is in reality present. The dip of the rocks, together with the topography at this locality, accounts for Storrs's error, for without careful and complete facing the bed presents every appearance of being fully the thickness assumed. At the time of Calvert's departure from the field a transit survey was being made to locate accurately the prospect pits and outcrop lines on or near Trout Creek, but at the date of completion of the present report the resulting map is not at hand. The distances cited should be considered, therefore, as only closely approximate. This map accompanies the report by Mr. R. Y. Williams regarding mining conditions.

In addition to the prospecting described in the foregoing paragraphs, every previously known exposure of coal on either side of Trout Creek was visited, faced up where necessary, and the bed examined. It was found that a short distance east of the creek the structure becomes complex in passing toward Bear Creek, for the rocks are much disturbed, and coal beds, where found, are badly crushed. The lower group of coals outcropping near the west side of the Adams claim of the Cunningham group was examined, but the coal appeared to be too impure to be of special value. A 6½-foot bed, previously undiscovered, was opened on the east side of Trout Creek opposite the 6-foot bed mentioned in the preceding paragraph. This bed appeared to be clean, and, although soft, was considered likely to yield a fair proportion of small lump coal. In spite of the steep dip (60°) the relation of the outcrop to the topography is such that it could be opened up readily near the level of Trout Creek, and a sample of considerable size presumably obtained. In view of the fact that this bed was considered as fairly representative in physical character of the average coal of the field possibly adapted for Navy use, it was finally selected as the one to be developed. Reports received subsequent to the departure of the geologists from the field, however, are to the effect that this bed proved a disappointment, owing to the structure encountered. This condition, though not fully foreseen, is not surprising, as it merely represents what is to be expected in underground development of any bed in the entire field.

CONCLUSION.

In conclusion the writer must state that in his opinion the current impression of the commercial value of the Bering River coal field is greatly exaggerated, owing mainly to a mistaken idea of local conditions in the field itself. It must be granted that the first impression gained by a hasty traverse of the various natural passageways across the field is that coal is abundant, for the streams crosscutting the coal measured expose beds at numerous places. Examination of many of these exposures is likely, moreover, to disclose the fact that the coal is for the most part of great purity, not usually being associated with bone or streaks of dirt as in other well-known fields; shaly beds and local shaly bodies or horsebacks are the most common form of impurity in the coals of this region. Chemical tests also bear out the feature of purity, as most analyses show a low ash content and a high calorific value. Other factors besides purity and seeming abundance are necessary, however, for the successful commercial development of any coal field, and it is with respect to those necessary factors that the general public has been misinformed.

In regard to the quantity of coal, it is undoubtedly true that in the aggregate the tonnage of the Bering River field is very large, but the notable lenticularity of the beds introduces a very uncertain factor. This factor has been recognized by various geologists who have visited the field, but a conclusion has been drawn therefrom to which the writer can not subscribe. The belief appears to have been that although the coal is likely to pinch out at any locality, there will be other localities where it will thicken sufficiently to counterbalance that effect. This line of reasoning would be more tenable could it be demonstrated that wherever a barren locality is encountered in underground workings the coal will reappear in normal or increased thickness a short distance beyond. In reality, however, reappearance at the same stratigraphic horizon seems improbable. No well-managed company would be likely, therefore, to risk the large expenditure necessary to drive far through barren strata to prove actual underground conditions. A good illustration of such conditions is displayed in connection with the 8-foot bed opened near the Cunningham Cabin on Trout Creek, to which reference has been made elsewhere in this report. Moreover, this condition is almost certainly the normal one in the field and should not be considered at all exceptional.

In regard to the physical character of the coal, with the exception of the anthracite district of Carbon Mountain, along the axes of close folds and in the immediate vicinity of large faults, the coal is soft and incoherent, so much so that it can usually be shoveled direct from the face. A considerable amount of coal from the McDonald mine—and this coal contains a larger percentage of small lump coal than the average of the field—was used in locomotives during the period of railroad activity near Katalla. It is claimed on what is considered good authority that the coal failed to remain on the grate under the slightest forced draft—a feature, if true, that would probably make it undesirable for use on naval vessels.

In regard to the cost of mining, even disregarding the frequent pinching out of the beds, the coal could be extracted only with an excessively high cost. Practically every drift or entry in the field discloses one or more faults, necessitating a large amount of dead work. Usually the roof is unsafe and requires careful timbering. The incoherent character of the coal, moreover, combined with the steep dips, causes a very unsatisfactory condition. The coal is so soft that excessively large pillars must be left to support the roof, thus greatly decreasing the amount available for extraction. The coal is apt to creep down the rise into the main entries, crushing any but the most substantial timbers. It is difficult to estimate the actual cost of mining the coal of this field, but every factor involved is such that it is certain to be much greater than is the case with the development of the coal fields in the States.

It is not the intention of the foregoing statements to convey the impression that the Bering River coal field is entirely without value. Fuel is there of good quality chemically and in large aggregate amount. In the writer's opinion, however, the best utilization of the coal will be to make it into coke and then to use it to smelt Alaskan ores of too low a grade to stand shipment to present smelting centers. The coke would most certainly be costly, but even so it might be used with economy in the manner suggested. Also, the soft, coking coal of the field might be briquetted to form an ideal domestic or steam fuel, but here again the cost would be prohibitive under present market conditions.

TRANSPORTATION OF BERING RIVER COAL SAMPLE FROM MINE TO TIDEWATER.

TRANSPORTATION OF COAL TO TIDEWATER.

The sacked coal was stowed in piles near the tunnels along Trout Creek. A wide sled trail with easy gradients was constructed from this point to the nearest navigable water—a point on Stillwater Creek about 5 miles distant. During the winter of 1912–13 the coal was sledded to this depot by means of double-end horse sleds, which carried about 2,000 pounds to the load. The actual sledding began January 15, 1913, and was concluded April 17, 1913. The late start was due to continued soft weather, and the progress of the work was seriously delayed at times by periods of thaws and rains. To accomplish this work 7 horses and sleds and 10 men were employed. This feature of the transportation was under the immediate charge of Hospital Steward R. Aikman of the Navy.

From the depot on Stillwater Creek the coal was transported to Chilkat, a point near the mouth of the Bering River, in boats, during the summer of 1913. The Chilkat depot was about 21 miles from the Stillwater depot.

Before the expedition took the field freighting on the Bering River had been limited to rather small consignments, and this was transported either in poling boats by "lining" or "tracking" them against the current or in small power boats. The expedition had a considerable tonnage to handle (about 300 tons upstream and about 800 tons downstream), so it was necessary to carry out some river-improvement work. Docks were built at Stillwater and Chilkat depots, and in several instances wing damming was undertaken to confine the river. The first 7½ miles of the river downstream from the Stillwater depot is a typical glacial stream of what was a delta region. The river was spread over great alluvial flats formed largely by the deposition of glacial silt and detritus and divided into many narrow shallow and tortuous channels. This was a region of innumerable sandbars and areas of quicksand. Considerable difficulty was encountered in navigating this division of the river. The lower 7½ miles of the river, or below Bering Lake (a tidal lake), was tidal and did not present any difficulties whatever.

On account of the variation in the depth of water in different sections or divisions of the river several handlings of the coal were necessary. The coal was loaded into large boats at the Stillwater depot. At the entrance to the delta region the coal was transferred to small shallow-draft boats, which were necessary to cross the bars. At the beginning of tidewater it was transferred to barges. The first coal arrived at Chilkat on June 23, 1913. The entire amount was delivered by July 29, 1913.

The coal mined by the expedition, which totaled about 600 tons, was delivered to the U. S. S. *Maryland*. Fifty tons were reserved for shipment to the Engineering Experiment Station at Annapolis, while the balance was consumed in steaming tests on board that vessel. The *Maryland* anchored in the Okalee Channel of Controller Bay, at a point about 10 miles from Chilkat depot. The coal was delivered alongside in barges. The total amount of coal lost in the entire transportation was about 9 tons, which is a surprisingly small amount and a very creditable performance on the part of the management. In all 33 boats and barges were used in the river transportation, 21 of which were built in the field by the expedition out of lumber milled on the ground. This total includes tenders for the large power boats and river skiffs used during the river-improvement operations. Thirteen of these boats were equipped with power, seven of which were built and the engines fitted or installed in the field. Engines were installed in two other power boats. Two large power boats and two barges were built at the navy yard, Puget Sound, and shipped to Alaska.

The boat-construction work was accomplished by a force of men detailed from the U. S. S. *Maryland*, under the direction of Lieut. Commander Mark St. C. Ellis, United States Navy, and Chief Carpenter A. W. Jones, United States Navy.

It was the original intention to sled the coal from the mines to tidewater during the winter, as it was thought this would give less difficulty than the river transportation. The many rains and thaws, during which the snow practically disappeared, precluded all possibility of utilizing this method.

This transportation of the coal from the tunnels along Trout Creek to tidewater was under the charge of Passed Asst. Surg. John O. Downey, United States Navy, who had been the representative of the Navy Department and the department fiscal agent during the mining operations.

COMPARATIVE STEAMING TESTS POCAHONTAS AND BERING RIVER COAL, CONDUCTED BY U. S. S. "MARYLAND."

1. The U. S. S. *Maryland*, an armored cruiser of 15,138 tons full-load displacement, was designated to conduct the comparative steaming tests of Pocahontas and of Bering River coals. This vessel has the following characteristics: Length over all, 503 feet 11 inches; beam, 69 feet 6½ inches; mean draft, 24 feet 1 inch; speed on trial, 22.41 knots; displacement on trial, 13,749 tons; bunker capacity to bottom of beams (43 cubic feet to the ton), 2,054 tons; main engines, 2 vertical 4-cylinder triple expansion; cylinder diameters, 38½ inches, 63½ inches, and 74 inches; stroke, 48 inches; boilers, 16 B. & W.; total grate surface, 1,600 square feet; total heating surface, 70,944 square feet; indicated horsepower of propelling machinery and auxiliaries on trial, 28,059.

2. The Bureau of Steam Engineering issued the following instructions for the comparative trials:

WASHINGTON, D. C., *April 16, 1913.*

From: Chief of Bureau of Steam Engineering.
To: Commanding officer of U. S. S. *Maryland.*
Subject: Instructions for steaming tests Bering River (Alaska) coal.

1. The bureau has been informed by the department that the U. S. S. *Maryland* will conduct the steaming tests to be held with Bering River coal recently mined in Alaska, and has been directed to draw up instructions for the tests.

2. At the present date this coal is in bags at Stillwater Creek awaiting the breaking up of the winter ice so that transportation to Controller Bay will be possible. Further notice will be given when the coal has arrived at Chilkat (Controller Bay), inasmuch as an estimate of time to bring the coal down the Bering River is hard to make at present.

3. In order to insure this coal being thoroughly cleaned, the bureau desires that the coal be inspected either before loading on the barges or upon arrival on board. Such cleaning as may be necessary shall be done in order to bring the coal up to a standard of well-cleaned run-of-mine. Also the bureau desires special inspection of the lump coal which was obtained from one of the mines in order to note its friability and the breakage in handling. This lump coal has been kept separate from the remainder of the coal for just such an inspection. After inspection this coal should be mixed with the remainder so that the entire lot may be of about the same grade. The number of cubic feet to the ton should be ascertained and reported.

4. The bureau desires two complete sets of tests, one to be with run-of-mine Pocahontas coal and the other with Bering River coal. Each set of tests shall consist of—

(I) An uninterrupted period of not less than seven days in port, during which time steam shall not be upon the main engines for any purpose. The auxiliaries in use shall be the same in both series of tests, equal duty to be performed. If any discrepancy unavoidably occurs, it shall be noted and allowance made therefor as noted below.

(II) A test at sea with not more than three-fourths boiler power and at a speed of about 15 knots. This test to last 24 hours.

(III) A test at sea under full boiler power at a speed of 20 knots. This test should last 4 hours.

(IV) A test at sea at a speed of 10 knots for a period of 48 hours.

The sequence of these four features of the test will be determined by you, but the sequence adopted for the first test must be followed during the second test.

5. Upon receipt of each coal to be used in these tests, samples for chemical analysis will be taken and forwarded to the Bureau of Steam Engineering. Care must be used to make these samples represent as nearly as possible the average of the entire lot of each coal. To this end small samples (shovelsful) should be taken throughout the coaling, the small samples to be placed in one pile, divided into quarters, and two of the quarters rejected, the other two to be crushed, this quartering and crushing to continue until a final sample of about 4 pounds is obtained. This is the sample for transmittal in a sealed receptacle to the bureau for analysis.

6. The bureau desires that all data of the tests be prepared by a board to be appointed by you, with instructions to include all the data called for herein, arranged in tabular form.

7. Should there be any difference in the auxiliaries used and duty performed by them, the board should allow therefor.

8. In the tests underway every effort shall be made to keep the revolutions corresponding to the prescribed speeds constant. Should discrepancy between the two tests unavoidably exist, the board should reconcile coal consumption by the formula laid down in the Rules for Engineering Competitions.

9. During the four-hour full-speed runs indicator cards should be taken once per hour; in the other runs, once per watch. The pounds of coal per horsepower should be computed by the board and entered in an appropriate column of the tabular report. The cruising radius at each speed should be calculated and reported.

10. Copies of the engineer's log for the period of the tests should be submitted. The results of flue-gas analysis should also be reported.

On each test all data required by the Rules for Engineering Competitions should be taken.

11. During the entire period of the test the strictest care must be taken to preserve the absolute accuracy of the coal accounts. The weight of the coal as originally received must be checked in as many ways as possible. These checks must be detailed in the board's report. The weight of the coal, as used on board ship, should be checked by frequent weighing of the buckets, as well as by inspection of the bunkers. The weight of the ash must be obtained accurately. The ash should be weighed dry, and not wet. The amount of clinker should be especially reported upon, and the board should attempt to determine the exact weight of the clinker. Any special difficulties in firing, or any special methods used in firing, should be described in the board's report.

12. During each test the bureau requests that particular attention be paid to the effect upon the grate bars of the different kinds of coal used. The number of grate bars that it is necessary to renew in order to put the boiler furnace in a fit condition for further general use shall be noted at the conclusion of each test and the result shall be included in the board's report. The bureau further desires to be informed concerning the amount of soot deposited on the boiler tubes. In each test special statements should be made of the frequency with which it is found necessary to clean the boiler tubes. The report should also state the relative amount of smoke made by the different kinds of fuel and the effect upon boiler casings of burning the different fuels. In reporting the amount of smoke use the Ringelmann scale and submit smoke records, together with appropriate photographs showing extreme and average conditions.

13. In view of the fact that the characteristics of Bering River coal, so far as giving off of explosive gases are concerned, is unknown, extra precautions should be taken in entering bunkers.

14. In every test the report should include a complete description of any unusual characteristics or peculiarity of the fuel that is tested. If, for example, any tendency to spontaneous compustion is noted, or if any special ease or difficulty in handling or stowing is experienced, or if any peculiar good or bad qualities are exhibited, the board's report should include a detailed statement of those qualities.

15. The report of the board should in each test include a specific recommendation stating whether or not the coal tested is recommended for future and more extended tests to determine its value for general naval use under standard service conditions.

16. At this time it is impossible to state definitely the quantity of Bering River coal that will be landed on board the Maryland. The conditions of transportation are such that loss of some of the coal may be expected. The order and length of the different portions of the test are, therefore, left to the discretion of the commanding officer. The complete full-power run must, however, be made, together with such preliminary work as will allow the firemen and water tenders to develop methods of firing this new coal.

17. The bureau wishes a complete description of the action of the coal on the grate, and the methods of firing. As many photographs as possible should be submitted in

order to show the general appearance of the coal when received, the character of the ash and clinker, the effect on grate-bar casings and uptakes, smoke, and (if possible) the appearance of the coal on the grate.

18. In order that the Pocahontas coal received may not be unduly weathered, Pocahontas coal cargo recently received should be taken on board at Tiburon or at Mare Island.

19. Attention is invited to the importance of the test of these coals, and to the necessity of care in taking and preparing the data. The Bering River coal represents a considerable outlay of money. Moreover, the report of the suitability or nonsuitability of this coal for naval use will have important bearing on the source of supply of coal for the Navy; and, possibly, will affect the interests of many citizens of the country. It is, therefore, requested that all operations of the vessel be made secondary during these trials in order that the tests may receive the undivided attention of the board.

H. I. Cone.

3. The board referred to in the letter of instructions was composed of the following officers: Capt. John M. Ellicott, United States Navy; Lieut. Milton S. Davis, United States Navy; Lieut. Herbert E. Kays, United States Navy.

This board conducted the trials with Pocahontas coal. Capt. John M. Ellicott, United States Navy, having been detached from the command of the *Maryland* prior to the Bering River tests; Commander Philip Andrews, United States Navy, served as senior member during the last-mentioned tests and also on the four-hour, full-boiler power, Pocahontas run.

COAL USED ON THE POCAHONTAS TESTS.

4. The coal used during the Pocahontas port test, 15-knot test, and 10-knot tests was received from the naval coal depot, Tiburon, Cal., on May 3,1913. This depot had received this coal on March 14–19, 1913, and March 20–27, 1913, from the chartered colliers *Inveran* and *Georgian*. These colliers had, in turn, received this coal at Lamberts Point, Va., on January 11–13, 1913, and January 22–24, 1913. The coal was from the following mines: Lynchburg, Page mines, Nos. 1, 2, and 3; Crozer, Nos. 1 and 2; Superior Pocahontas, No. 1; Goodwill, Nos. 3 and 4; Powhatan, Louisville, No. 1; Upland, Pawana, Nos. 1 and 2; Greenbrier.

Analysis of representative samples of this Pocahontas coal gave the following results:

Moisture, as received	per cent..	2. 50
Volatile	do....	19. 10
Fixed carbon	do....	74. 60
Ash	do....	6. 30
Sulphur	do....	. 70
British thermal units		14, 630

At the end of the trials the board reported this coal to contain but a small percentage of lump; that the loss through the grates was small, and that it was found to be an excellant steaming coal, requiring only moderate working and not clinkering badly.

The Pocahontas coal used on the four-hour full-boiler power run was received from the navy yard, Mare Island, Cal. This coal had been delivered at Mare Island by the steamer *J. A. Hooper*, which steamer had in turn been loaded at Lamberts Point, Va., on December 2–3, 1912. This coal was from the following mines: Empire, Virginia, Pocahontas, Arlington, Central, Turkey Gap, and Hiawatha. Analysis of representative samples of this coal gave the following results:

Moisture, as received	per cent..	2.30
Volatile	do....	17.90
Fixed carbon	do....	73.70
Ash	do....	8.40
Sulphur	do....	.54
British thermal units		14,330

At the end of the trial the board reported this coal to be of excellent quality, with a moderate amount of slack and not weathered; and that little ash and clinker resulted therefrom.

COAL USED ON THE BERING RIVER TESTS.

5. This coal was the Bering River coal, received by the *Maryland*, at Controller Bay, on July 31–August 3, 1913, as previously noted. This coal when received was exceedingly wet and had not been satisfactorily cleaned. The board noted that the lump was clean, bright, but friable; that the lumps were generally free from coal bone; but that the slack appeared to include sand or powdered shale or slate. Analyses (moisture free) of two representative samples of the coal, taken while loading at Controller Bay, as laid down in the instructions from the Bureau of Steam Engineering, gave the following results:

	Sample No. 1.	Sample No. 2.
Volatiles	17.70	16.70
Fixed carbon	61.90	59.90
Ash	20.40	23.40
Sulphur	.65	.60
British themal units per pound	12,180	11,740

The moisture content taken by the board was 5.2 per cent.

In view of the necessity of drying and recleaning, the coal was loaded into empty bunkers and taken to the navy yard, Mare Island, Cal., where it was unloaded and subjected to four screenings, the smallest mesh being one-half inch. The slack was not washed. All coal was dried, the resulting analyses of 10 samples showing as follows:

Kind.	Percentage.	Moisture.	Volatile.	Fixed carbon.	Ash.	Sulphur.
Lump	10.0	0.40	17.25	79.16	3.09	....
Nut	12.5	.83	17.50	79.44	2.33	0.72
Pea	31.0	.50	16.65	73.07	9.78	....
Slack	46.5	.90	15.62	55.82	27.66	....

The percentages quoted refer to the total weight prior to picking out 1.7 per cent slate and removing about 4.5 per cent of moisture by drying.

The coal having been dried and cleaned, it was placed on board the *Maryland* for test.

The composite analysis of this reclaimed and dried coal is as follows:

Moisture	0.73
Volatile	16.34
Fixed carbon	66.44
Ash	16.49

SEVEN DAYS' PORT TEST.

6. The seven days' port test with Pocahontas coal was held from 8 a. m. May 5 to 8 a. m. May 12, 1913, and with Bering River coal from 8 a. m. August 14 to 8 a. m. August 21, 1913. Boiler No. 8 was used in both cases; the load on the ship being the same in both cases, the difference being only one-third of 1 per cent. The coal, water, ash, and clinker were weighed and accurately tallied.

The same grade of run-of mine coal was used during the entire week that Pocahontas coal was tested. During the Bering River port test screened lump was used for two days, run-of-mine for two days, and slack for three days.

The comparative results of these tests are as follows:

	Average water evaporated per day.	Average coal per day.	Average coal per day equal duty.	Percentage of ash and clinker dry.	Percentage clinker in ash.	Smoke density (Ringelmann).	Average CO_2.	Relative efficiency.
	Gallons.	*Tons.*	*Tons.*					
Pocahontas run-of-mine	35,515	13,470	13.47	11.04	27.3	0.9	8.41	100.0
Bering River screened lump	36,442	17,412	16.97	25.55	53.7	1.1	10.95	79.4
Bering River run-of-mine	37,813	20,021	18.80	30.85	42.95	1.1	11.00	71.7
Bering River slack	33,092	20,509	22.01	39.07	40.40	.8	8.9	61.2

The final comparative results, reconciled for equal duty, are as follows:

Kind of coal.	Tons of coal used equal duty.	Comparative efficiency.
		Per cent.
Pocahontas	94.291	100.0
Bering River	136.840	68.9

CONCLUSION.

Neither the screened lump, the run-of-mine, or the slack Bering River coal is the equal of Pocahontas coal for this duty.

FOUR-HOUR, FULL-POWER, FORCED-DRAFT, 20-KNOT TRIALS.

COAL USED.

Pocahontas run-of-mine and Bering River run-of-mine, as previously described.

TRIAL WITH POCAHONTAS COAL.

This trial was held on August 29, 1913, from 11 a. m. until 3 p. m. All boilers were in use under moderate forced draft. The 20-knot speed was maintained with the greatest ease and with little effort on the part of the firemen. There was but little ash or clinker, and the boilers were fairly clean at the end of the run. The smoke was heavy and black, with a moderate amount of cinder.

TRIAL WITH BERING RIVER COAL.

This trial was held on August 26, 1913, from 3 p. m. to 7 p. m. All boilers were in use with 2 inches air pressure. Clinkers and ash in excessive quantities were produced. Every effort was made to make a speed of 20 knots, the firemen working to the point of collapse. Constant removal of clinker was necessary. The average speed made was 18.6 knots, the highest attained being 19.3 during about 15 minutes of the time, while using lump coal. No damage to boilers or uptakes was found after the trial. Two grate bars were renewed.

The absence of smoke on this forced-draft run was remarkable, and in contrast with the heavy black smoke noted on the Pocahontas run. The smoke from Bering River coal was light brown, almost transparent, easily dissipated, and in general less pronounced than that ordinarily made in port by the *Maryland*.

With fires sufficiently thin for good combustion steam could not be maintained, and much coal fell in the ash pans. After the coal had coked, it packed into a solid bed, which offered resistance to the air so as not to admit sufficient air for good combustion. Where air currents found their way through the coal, bed clinkers formed very rapidly. Some clinkers were of such size as to require breaking up before they could be removed through the furnace doors. The coal was generally slack, with few lumps.

The comparative data of these trials are set forth in the following table:

	Pocahontas.	Bering River.
Average speed, knots	20.2	18.56
Coal used, tons	79.1	127.3
Coal used, equal duty, tons	79.1	[1] 184.7
Per cent ash and clinker, dry	8.8	38.8
Per cent clinker, in ash	4.7	17.4
Smoke density, Ringelmann	2.4	1.5
Per cent CO_2	8.2	5.9
Average temperature uptakes, °F	583	551
Average indicated horsepower, main engines	20,820	13,992
Pounds coal per indicated horsepower, based on indicated horsepower of main engines only	2.14	5.09
Knots per ton, at 20.2 knots	1.02	.437
Coal, cubic feet per ton	39.9	39.83
Cruising radius, 20.2 knots speed	2,257.7	969

[1] Based on indicated horsepower, given in tenth line, taking 639 as the indicated horsepower of auxiliaries in use with Pocahontas and 789 with Bering River, and assuming that the total coal will be in proportion to the total power actually developed and the total power necessary for 20.2 knots.

The final comparative results are as follows:

Kind of coal.	Coal used, equal duty.	Relative efficiency.
	Tons.	
Pocahontas	79.1	100.00
Bering River	184.7	42.83

CONCLUSIONS TO BE DRAWN FROM THIS TEST.

1. Full speed can not be maintained with Bering River coal. A speed of 18.56 knots was all the ship's force could make on this trial with this coal. This represents only half the power necessary to drive the ship at full speed.

2. The quantity of ash and clinker produced by Bering River coal and the necessity of constant clinkering of fires throws such exhausting work upon the personnel as to make impossible moderate speed except for a short period.

3. Bering River coal is far superior to Pocahontas in smokeless qualities.

4. Although the firing appears to have been better with Pocahontas coal than with Bering River, the discrepancies in coal consumptions are so great that it can not be expected that Bering River coal can compare in efficiency with Pocahontas.

CONCLUSION.

Bering River run-of-mine coal is unsuitable for use with forced draft in naval boilers.

24-HOUR THREE-FOURTHS BOILER POWER, 15-KNOT TESTS.

WITH POCAHONTAS COAL.

This run was made from 6 p. m., May 12, 1913, to 6 p. m., May13, 1913. Boilers 1–10 were in use under natural draft. Fires were carried from 7 to 8 inches thick. One grate bar was renewed. Loss of coal through grates negligible. There was no noticeable effect on boilers or uptakes.

WITH BERING RIVER COAL.

This run was made from 12 midnight to 12 noon August 27, 1913. Due to the large expenditure of coal this run was shortened to 12 hours. Boilers 1–14 were tried, but it was found that they could not make enough steam to maintain a speed of 15 knots, so two more boilers—all boilers—were added. Fires were carried from 5 to 8 inches thick with natural draft and 8 to 10 inches with forced draft, it being necessary to run some of the blowers. At the beginning of the run the loss through the grate bars was estimated at 40 per cent, as the coal was very slack. Later, the loss became very low. Two grate bars were renewed. After the run there was no noticeable effect on the uptakes and stacks, though the temperatures were higher in general than with Pocahontas coal. There was an accumulation of soot and fine ash all through the tubes, and the boilers were found to be dirty. Nine anchor clamps, 4-inch tubes to casing, were burned off, one baffle door was warped, and one cast-iron block between center 4-inch tubes was burned. There was no sagging or bulging of tubes, and no warping or displacement of flame plates.

The fires clinkered badly and great quantities of ash were produced. The clinkers were very easily broken, but it was necessary to remove them almost continually from the fires.

The comparative data of these trials, reconciled for the same length of time, are set forth in the following table:

Kind of coal.	Pocahontas.	Bering River.
Average speed, in knots	15.10	14.66
Coal used, tons	76.58	160.30
Revolutions per minute	86.2	82.9
Per cent ash and clinker, dry	7.6	35
Per cent clinker in ash	23.1	10.9
Smoke density, Ringelmann	1.25	.6
Average CO_2	7.8	4.4
Average temperature, uptakes, °F	347	426
Coal, cubic feet per ton	42.23	39.83

Reconciled for equal duty, the results are as follows:

Kind of coal.	Coal used, equal duty, 15.1 knots.	Relative efficiency	Knots per ton at 15.1 knots.	Cruising radius, 15.1 knots.
Pocahontas	76.58	100	2.37	4,956.8
Bering River	173.3	44.2	1.05	2,317.3

In anticipation of making the tests much earlier, the run with Pocahontas was made three months earlier than that with Bering River coal, which would tend to make the result with the latter less favorable in point of speed and indicated horsepower than it should have been, due to the longer time out of dock. The indicated horsepower of the main engines reported with Pocahontas was 7,083, and that with Bering River 7,600, but investigation of the data shows that the latter figure was the indicated horsepower for the last nine hours of the test, during which the revolutions per minute averaged 85. During the first three hours the revolutions varied from 71.3 to 83.1 and it is probable that the average indicated horsepower for the 12 hours did not exceed 7,350. Under identical conditions, there would, therefore, be necessary a slight correction for Bering River, which would not make any material difference in the figures above recorded.

CONCLUSIONS TO BE DRAWN FROM THIS TEST.

1. The percentage of ash and clinker in Bering River run-of-mine is excessive, thereby throwing exhausting work upon the personnel.

2. More boiler power, and to a certain extent forced draft, had to be used with Bering River coal for equal duty. Although the firing appears to have been better in the Pocahontas test than in the Bering River, the discrepancy in coal consumption is too great to allow a hope for results with Bering River coal that may in any way compare favorably with those attained with Pocahontas.

3. Bering River coal is superior to Pocahontas in smokeless qualities.

4. The number of miles that can be steamed with Bering River on one bunkering is much smaller than can be accomplished with Pocahontas—approximately one-half. That is to say, with Pocahontas coal the *Maryland* could steam from San Francisco to Yoka-

hama direct and arrive with approximately 300 tons in her bunkers, while with Bering River she could steam only as far as Honolulu and arrive with the same amount in her bunkers.

CONCLUSION.

Bering River run-of-mine coal is inferior to Pocahontas.

FORTY-EIGHT HOUR 10-KNOT TEST.

In view of the unexpected large coal consumption with Bering River coal during the other tests, no coal was available for this test. The absence of these data is not felt, however, in view of the data furnished during the other trials.

FINAL CONCLUSION FROM THE FOREGOING TESTS.

Bering River run-of-mine coal is unsuitable for naval use.

In order to test accurately the suitability of screened and washed Bering River coal, the coal to be tested at the Engineering Experiment Station, United States Naval Academy, Annapolis, Md., was screened and washed to represent the best grade that can be expected from the Bering River fields. The results of this test are noted in the next report.

SUMMARY OF RESULTS OF THE COMPARATIVE TEST OF WASHED AND SCREENED BERING RIVER COAL AND OF POCAHONTAS RUN-OF-MINE COAL AT THE ENGINEERING EXPERIMENT STATION, UNITED STATES NAVAL ACADEMY, ANNAPOLIS, MD.

By T. W. Kinkaid.

United States Naval Academy,
Engineering Experiment Station,
Annapolis, Md., February 13, 1914.

To: Bureau of Steam Engineering.
Subject: Summary of results of evaporative test of Bering River, Alaska, coal.
Reference: (a) Bu. S. E. letter No. 117391–623–15, of February 11, 1914.

1. Complying with the bureau's instructions, there is submitted below a summary of the results of comparative tests of Pocahontas and Bering River, Alaska, coals.

2. The Bering River coal is part of a lot of 587 tons mined by the Alaskan coal expedition, and the Pocahontas coal is run-of-mine from Pocahontas No. 1 Mine, Tazewell County, Va. Representative samples of the two coals were sized to determine the proportion of lump and fine coal in each, with the following results:

Size of screenings.	Pocahontas.	Bering River.
	Per cent.	*Per cent.*
Lump over ⅞-inch mesh	32.56	25.37
Coal through ⅞-inch and over ½-inch mesh	11.15	11.95
Coal through ½-inch and over 4-inch mesh	13.21	17.24
Coal through 4-inch mesh and over 10-inch mesh	31.05	20.62
Slack through 10-inch mesh	11.56	23.95
Hand-picked slate	.47	.87
Total	100.00	100.00

3. The Pocahontas coal is considerably more friable than Bering River, as 2.39 times as much of the former as of the latter will break to pass through 4-mesh when lumps of various sizes are dropped on a solid concrete floor from a height of 10 feet. The Bering River coal has a luster and hardness closely resembling that of anthracite, does not break readily, but shows a bright fracture when broken. The waste material is in the form of a carbonaceous shale of high specific gravity varying in appearance from the good coal in luster and shape of particle. The shale is a hard material which does not have as brilliant a luster as the coal and exists in the shape of flat fragments, whereas the good coal is irregular in size and shape. The Bering River coal as mined contains 14.06 per cent ash in dry coal and has a

heating value of 13,286 British thermal units per pound of dry coal. Pocahontas coal has 5.66 per cent ash in dry coal and a heating value of 14,786 British thermal units per pound of dry coal.

4. Hand-picked Bering River coal over seven-eighths inch screen equals in thermal quality average Pocahontas run-of-mine coal and can scarcely be differentiated from it chemically. Screened sizes of Bering River coal increase in ash content as the sizes of mesh through which the coal is handled is decreased. The sulphur content of Bering River coal, regardless of size or ash content, is uniformly as low as that of Pocahontas coal.

5. In order to produce a fuel which was approximately as good chemically as Pocahontas coal, the Bering River coal was cleaned in a coal washery plant designed and built at the experiment station. In the cleaning process there was entirely discarded the slack through 10-mesh, it forming over 20 per cent of the entire lot and containing 26.54 per cent ash in dry coal. The coal was separated into sizes and washed. The resulting washed coal, consisting of 67.6 per cent of the original weight after discarding slate refuse and high ash slack, contained 7.32 per cent ash in dry coal and had a heating value of 14,453 B. t. u. per pound. As only the best grade of coal was desired for test, there was a further rejection of washed screenings 4 to 10 mesh, and the coal as fired was a mixture of hand-picked lump over seven-eighths-inch screen, washed nut seven-eights-inch to one-half inch, and washed pea coal one-half-inch to 4-mesh. This mixture showed on analysis ash in dry coal of 5.42 per cent and a heating value of 14,844 B. t. u. per pound. Thus with a loss of 49.6 per cent of original coal it was possible to prepare a mixture which had an ash content 0.24 per cent lower than Pocahontas coal and a heating value 0.39 per cent higher, with a reduction in ash content from an original of 14.06 per cent to 5.42 per cent.

6. The evaporative tests, each of 24 hours duration, were made on a Babcock and Wilcox marine boiler under the following general test conditions:

Number of furnace doors	3
Heating surface, square feet	2,161
Grate surface, square feet	58⅓
Steam pressure, pounds gauge	300
Draft at base of stack, inches of water	0.75
Feed temperature, °F	185
Firing interval for one door, minutes	5
Cleaning interval for one furnace, hours	12

7. Coal and water were accurately weighed and all necessary observations of pressure, temperature, and general weather conditions were taken. The condensed results of the evaporative tests are:

	Pocahontas.	Bering River.
Total water evaporated, pounds	322,831	241,791
Total coal consumed, pounds	35,740	27,160
Water per hour, pounds	13,451	10,075
Dry coal per hour, pounds	1,454	1,114
Water actually evaporated per pound dry coal, pounds	9.25	9.05
Equivalent evaporation per pound dry coal, pounds	10.04	9.77
Boiler efficiency, per cent	65.89	63.87
Boiler horsepower developed	422.9	315.5
Builder's rating	216.1	216.1
Per cent rating attained	195.7	146.1
Dry coal per square foot grate surface, pounds per hour	24.95	19.11
Equivalent evaporation per square foot heating surface, pounds per hour	6.75	5.04

8. The Bering River coal when first fired on a clean grate burns with a fierce fire and produces a high evaporation. Gradually, however, a dense clinker forms which fuses to the grate bars, filling the air spaces and preventing the entrance of sufficient air for combustion. During the first hour of the test the evaporation was 14,872 pounds of water and 1,814 pounds of coal were burned. In three hours the hourly evaporation had fallen to 10,731 pounds and the corresponding coal consumption was 1,263 pounds. From that time, although the greatest effort was made to break up this clinker by slicing through the fire door and driving a sharpened pricker bar between the grate bars from the ash pit below, the evaporation remained low. The minimum rate was 7,114 pounds per hour and the maximum 11,113, the corresponding coal consumption being 660 and 1,159 pounds. Not only at cleaning periods when the boiler pressure fell some 50 pounds, but frequently in between times it was impossible to maintain full boiler pressure. No coke is formed during combustion and very little ash falls through the grate on account of the clinker between grate bars. Smoke is much lighter than with Pocahontas coal, due in part to much lower rate of driving.

9. In spite of the care in preparation of the Alaskan coal for test, wherein the ash content was reduced to as low a figure as that found in Pocahontas coal, the test shows that the coal is entirely unsuited for use on standard Navy grate bars on account of—

(*a*) Dense clinker formed on grate.

(*b*) Reduction in boiler capacity from 195.7 to 146.1 per cent of rating.

(*c*) Decrease in boiler efficiency of 2 per cent as against Pocahontas run-of-mine.

(*d*) Forty-eight and six-tenths per cent loss in preparation.

(*e*) A cost of approximately $6.34 per ton cleaned coal at the point of preparation.

(*f*) Increased labor of furnace cleaning beyond the endurance of the average fireman.

REPORT IN DETAIL OF THE COMPARATIVE TEST OF WASHED AND SCREENED BERING RIVER COAL AND OF POCAHONTAS RUN-OF-MINE COAL AT THE ENGINEERING EXPERIMENT STATION, UNITED STATES NAVAL ACADEMY, ANNAPOLIS, MD.

[First indorsement.]

UNITED STATES NAVAL ACADEMY,
Annapolis, Md., February 4, 1914.

From: Head of Naval Engineering Experiment Station.
To: Bureau of Steam Engineering.
Subject: Comparative evaporative test of Pocahontas and Bering River (Alaska) coal.
References: (*a*) Bu. S. E. letter 103463–623–15–F, of August 12, 1913; (*b*) Department's letter 25320–77, of September 8, 1913; (*c*) Bu. S. E. letter 103463–623–15, of September 22, 1913.
Inclosure: (A) Report of test.

1. Forwarded, approved.

2. Mr. G. R. Delamater, referred to in paragraph 23 of the report, was detailed by the Bureau of Mines to cooperate with this station in regard to preparation of the Bering River coal for test. Mr. Delamater's report in regard to the washery operations has not yet been received. It will be forwarded later as a supplementary report.

T. W. KINKAID.

UNITED STATES NAVAL ACADEMY,
ENGINEERING EXPERIMENT STATION,
Annapolis, Md., February 2, 1914.

From: Loeb, Leo, mechanical engineer.
To: Head of Naval Engineering Experiment Station.
Subject: Comparative Evaporative Test of Pocahontas and Bering River (Alaska) Coal.
References: (*a*) Bu. S. E. letter 103463–623–15–F, of August 12, 1913; (*b*) Department's letter 25320–77, of September 8, 1913; (*c*) Bu. S. E. letter 103463–623–15, of September 22, 1913.
Inclosures: (A) Coal analyses of samples from screening tests; (B) Table I, drawing No. 483, summary of dry coal analyses of samples from screening tests; (C) float and sink tests, Bering River coal; (D) float and sink tests, Pocahontas coal; (E) photograph, Bering River coal as received; (F) photograph, Pocahontas coal as received; (G) photograph, screened Bering River coal; (H) photograph, shaking screen for sizing Bering River coal; (I) general layout of washery plant, drawing No. 484; (J) photograph of washery plant; (K) details of coal washery, drawing No. 485; (L)

coal analyses of samples from washery operations; (M) Table II, drawing No. 486, summary of dry coal analyses of samples from washery operations; (N) Table III, data and results of washery operations; (O) Table IV, data and results of evaporative tests; (P) coal, ash, clinker, and soot analyses from evaporative tests; (Q) photographs of stack during evaporative tests; (R) recording pressure gauge records; (S) recording feed thermometer records; (T) recording stack draft records.

1. In its letter, as above reference, the Bureau of Steam Engineering directed this station to make comparative evaporative tests under identical full-speed conditions of a representative Pocahontas run-of-mine coal and of coal mined by the Alaskan coal expedition in the Bering River field. Upon the arrival of the U. S. S. *Maryland* at Mare Island 50 tons of the Bering River coal were loaded in a closed car for shipment on August 21, 1913. The routing of the shipment was via Sunset & Gulf, rail to Galveston, boat to New York, and rail to Annapolis, where it arrived September 16, 1913. The coal was shipped in 415 bags of a total net weight of 98,000 pounds. About one-fourth of the bags was exposed to rain during the unloading period, but the remainder was not so exposed. The coal was stored under cover and retained in bags until screened.

2. The coal as mined was a mixture of coals from the Trout Creek workings of the Bering River district and is commercially designated as Bering River mine No. 4 and Bering River mine No. 5 (big vein). The tidewater outlet of this coal is Controller Bay. The total amount of fuel mined by the expedition was 587 tons, the major portion of which was used for steaming tests on the *Maryland*.

3. The Pocahontas coal used in the comparative test was in a car selected at random from the coal yard at Bluefields, Va., on August 16, 1913, and arrived at Annapolis August 25, 1913. The detailed description of the coal as given by the Bureau of Supplies and Accounts is—

(*a*) Name of mine: "Pocahontas Mine No. 1," otherwise known as "Baby Pocahontas Mine."
(*b*) Operating company: Pocahontas Consolidated Collieries Co. (Inc.)
(*c*) Location of mine: Pocahontas Field, Tazewell County, Va., near Pocahontas.
(*d*) Coal bed: "Pocahontas No. 3 vein."
(*e*) Preparation at mine: Straight run of mine.
(*f*) Date of shipment from mine: August 13, 1913.
(*g*) Gross tonnage: 45.1786.
(*h*) Price of coal: $1.50 per ton (of 2,240 pounds) at the mine.

The coal was dry when received and was stored under cover until used. A week previous to the evaporative test the pile was wetted down to prevent too large a dust loss, as the coal was very dry.

4. On September 20, 1913, a joint inspection of the fuels was made by officers representing the Bureau of Steam Engineering, Bureau of Mines, and the Engineering Experiment Station, following which it was decided to select representative lots of the two coals for screening tests in order to determine the proportion of lump and fine coal of each variety and the character of the lump. Complying with instructions in paragraph 6 of reference (*a*) the first screening was performed through a wire-mesh screen made at the station, consisting of one-eighth-inch wires accurately spaced 1 inch on centers so that the width of the space was exactly seven-eighths

inch. Additional screens were made up from woven wire in store such that the mesh would be a gradual reduction from the largest of seven-eighths-inch mesh to the finest of 10 meshes per inch. The wire screens used had the following dimensions:

Commercial size.	Center to center of wires.	Diameter of wires.	Net width of spaces.
	Inches.	*Inches.*	*Inches.*
⅞-inch	1.000	0.128	0.872
½-inch	.516	.045	.471
4-mesh	.255	.028	.227
10-mesh	.100	.040	.060

Any future reference to these screens will be to commercial size.

I. PRELIMINARY EXAMINATION OF COALS.

5. The preliminary examination of the two coals under test may be summarized under three headings:

(*i*) Screening tests.
(*j*) Float and sink tests by the Bureau of Mines.
(*k*) Physical examination.

Wherever possible samples were selected for chemical analysis and forwarded to the Pittsburgh, Pa., laboratory of the Bureau of Mines. This bureau cheerfully and promptly proceeded with the large number of analyses required and rendered valuable assistance and advice in regard to such test operations as related strictly to coal mining and coal preparation.

6. The initial screening tests were made under the supervision of Mr. Chas. Enzian, mining engineer, Bureau of Mines, Wilkes-Barre, Pa. The procedure was to take about a ton of coal of each variety and screen through the seven-eight inch screen. The coal remaining on top of the screen washand-picked for slate and separated into two lots, one of lumps larger than 3½-inch and the balance larger than seven-eighth inch. The coal making up the lump and that forming the screenings was quartered and finally reduced to pass a 4-mesh screen before being sealed in the standard 3-pound sample tins supplied by the Bureau of Mines. The Bering River coal remaining from the rejected quarters was then screened through the smaller meshes and samples taken in like manner. At a later date a sample of Pocahontas coal was screened through the entire series of screens as a direct comparison to the results from Bering River coal. The gross sample of Pocahontas coal originally selected was 2,009½ pounds and the composition of the run-of-mine mixture was –

Size.	Weight.	Per cent.
	Pounds.	
Hand-picked slate on ⅞-inch	12½	0.62
Lump larger than 3½-inch	450½	22.42
Lump ⅞-inch to 3½-inch	428¼	21.32
Coal through ⅞-inch screen	1,118¼	55.64
Gross sample	2,009½	100.00

7. A second and larger sample of 5,025 pounds was carried through the series of screens with the following results:

Size.	Weight.	Per cent.
	Pounds.	
Hand-picked slate on ⅞-inch	23½	0.47
Lump larger than 3½-inch	553	11.00
Lump ⅞-inch to 3½-inch	1,083	21.56
Through ⅞-inch and over ½-inch	560½	11.15
Through ½-inch and over 4-mesh	664	13.21
Through 4-mesh and over 10-mesh	1,560	31.05
Slack through 10-mesh	581	11.56
Gross sample	5,025	100.00

8. The proportions of Bering River coal, as given by a gross sample of 2,122¾ pounds, the contents of nine bags selected at random, were:

Kind of sample.	Weight (pounds).			
	On ⅞-inch screen.	On ½-inch screen.	On 4-mesh screen.	On 10-mesh screen.
Slate	18½			
Lump over screen	538½	251¼	335½	399¾
Coal through screen	1,565¾	1,299¼	867	464¼
Gross sample	2,122¾	1,550½	1,202½	864

9. Reduced to percentage of original as received sample the results are:

Size.	Per cent.
Hand-picked slate on ⅞-inch	0.87
Lump over ⅞-inch	25.37
Through ⅞-inch and over ½-inch	11.95
Through ½-inch and over 4-mesh	17.24
Through 4-mesh and over 10-mesh	20.62
Slack through 10-mesh	23.95
Total	100.00

10. The analyses of the samples secured from the screening tests as reported by the Bureau of Mines are given in inclosure (A) and summarized on the dry basis in Table I, inclosure (B). The samples were prepared by Mr. Chas. Enzian, mining engineer. An inspection of these analyses indicates the following:

(*l*) Hand-picked Bering River coal over seven-eighth-inch screen equals in thermal quality average Pocahontas run of mine and can scarcely be differentiated from it chemcially.

(*m*) Screened sizes of Bering River coal increase in ash content as the sizes of mesh through which the coal is handled is decreased.

(*n*) The ash and moisture free thermal value of the Bering River coal decreases with ash content.

(*o*) The sulphur content of Bering River coal regardless of ash content is uniformly as low as Pocahontas coal and is subject to slight change with ash content.

(*p*) The fusing temperature of the ash as determined in a reducing atmosphere in a molybdenum furnace shows no uniform variation with size or ash content for either of the coals examined, but the fusing temperature for Pocahontas coal is on the average 72° higher than that of Bering River. The lack of uniformity of these results leaves much to be desired in the determination of a factor which is supposed at least to be an index to the tendency to form clinker.

(*q*) The ash content is lower and the heating value of the Pocahontas coal is higher for small sizes than for large sizes. This is due to the fact that the fines are derived from the purer coal, which is very friable; and the slate and shale, which is somewhat harder, tends to remain as separate particles and as a lump binder with the larger sizes. The free or extraneous ash in the Bering River coal is free from the coal and in its broken condition tends to be associated with the fines rather than with the lump which can more easily be hand-picked at the mine.

(*r*) The ash and moisture free heating values of the Pocahontas coal for all sizes are very uniform and slightly higher than that for Bering River coal.

(*s*) The specific gravity of Bering River coal is from 0.12 to 0.16 higher than that of Pocahontas.

11. The tabulation of coal analyses indicated clearly that it was necessary to wash or otherwise clean all sizes of Bering River coal smaller than seven-eighths-inch mesh, to make the coal approach in quality best run-of-mine Pocahontas. In order to determine the betterment to be expected from washing, a sample of 490 pounds was taken by opening a number of bags and taking from each a shovelful of coal. The sample was quartered without crushing and the rejected quarters furnished the sample for the first analysis of Table I, "As received not cleaned or screened," Bureau of Mines No. 17736. The quarters retained were placed in a tight can holding 108 pounds and forwarded to Pittsburgh October 3, 1913. The results of the float and sink tests are given in report "Float and Sink Tests, Bering River Coal," from Geo. S. Rice, chief mining engineer to the Director, Bureau of Mines, under date of October 11, 1913, appended to this report as inclosure (C).

12. The procedure in the preparation of the coal for float and sink test is outlined in the memorandum of Mr. Rice and that of Mr. A. C. Fieldner, chief chemist. The method followed in making the float and sink tests proper consists in preparing zinc chloride solutions of densities 1.35, 1.45, 1.55, and 1.65. The coal to be tested, after being properly sized, is immersed in the solution of lowest specific gravity, thoroughly stirred to insure intimate mixture of the coal and solution. The floating mass of less specific gravity than the solution is skimmed off, washed, and weighed, the solution then poured off and the sink of greater specific gravity than the solution is collected, washed, and weighed. The sink from the first solution becomes the gross sample for the second solution, the float and sink fractions again collected, the sink becoming the gross sample for the third solution—and so on through the entire series. A sample for ash determination is taken from each fraction.

13. The results of the float and sink test are more favorable than is to be expected from a representative sample of Bering River coal, since the ash in raw coal, dry basis, is but 10.49 per cent, whereas the

other quarter of the same lot of coal, sample 17736, gave 14.06 per cent ash in dry coal and all other determinations range from 14 to 15 per cent. This variation of 3½ per cent can not be explained, as the discrepancy runs through all sizes, other than to the fact that the sample weight, gross 490 pounds, was not large enough to be thoroughly representative of a coal representing a mixture of fuels from several workings.

14. The results of the float and sink tests show that with fractions 1 inch to one-half inch, one-half inch to one-fourth inch, one-fourth inch to 10-mesh, and 10-mesh to 60-mesh, containing, respectively, 6.68, 9.25, 13.14, and 20.25 per cent ash in dry coal and being 44.6, 17.0, 19.2, and 15.0 per cent of original coal, it is possible to separate into float on 1.65 specific gravity coals having 3.40, 3.49, 4.13, and 4.74 per cent ash in dry coal and a sink comprising refuse showing 66.39, 74.61, 73.91, and 70.07 per cent ash in dry coal, the sink forming 5.21, 8.11, 12.92, and 23.74 per cent of the respective fractions, not including 4.2 per cent of original coal finer than 60-mesh and containing 25.01 per cent ash in dry coal. The only departure from the comments and conclusions of Mr. Rice is first at the end of paragraph 5 where he states "but it is probable that the coal can be washed so that it will contain less than 5 per cent and possibly 4 per cent ash." Since one fraction runs as high as 4.74 per cent ash in dry coal for float on 1.65 specific gravity, it would be considerably more conservative on account of a reasonable limit to the water used in washing and the rate of jigging to fix the limits of ash in dry coal of washed coal between 6 and 8 per cent. Secondly, Mr. Rice states that "there would be little difficulty in making the separation with a good coal-washing system, at least for coal over 60-mesh in size. As only 4.2 per cent passed through 60-mesh this might be thrown away without the loss being serious, since it would represent only a small fraction of the total." As a matter of fact slack finer than 10-mesh representing 19.2 per cent of the total is so high in ash as to be washed with the greatest difficulty and is entirely unsuited to naval use.

15. To establish a basis of comparison between the two coals as shown by float and sink tests with solutions of the same density as that used with the Bering River coal, a set of samples of Pocahontas coals from the quarters retained after screening tests was forwarded to the Bureau of Mines, Pittsburgh, Pa., on October 25, 1913. The samples were:

2 bags, weight 76 pounds, lump over seven-eighth inch screen.
1 bag, weight 39 pounds, through seven-eighth inch and over one-half inch screen.
1 bag, weight 21 pounds, through one-half inch and over 4-mesh.
1 bag, weight 21 pounds, through 4-mesh and over 10-mesh.
2 cans, weight 6 pounds, screenings through 10-mesh.

16. The results of the float and sink test are contained in the data "Chemical Laboratory Report," inclosure (D). These tests again indicate the superior quality of the fines from Pocahontas coal over the coarser samples. Ranging in size from lump over seven-eighth inch screen to slack through 10-mesh on 60-mesh the fractions show 98 per cent float on 1.65 specific gravity with dry-ash contents of 5.16, 5.12, 4.15, 2.87, and 2.30 with 2 per cent sink, containing 55.75, 63.98, 67.86, 72.31, and 71.61 per cent ash in dry coal. The original ash dry-coal analyses of the portions showed 6.19, 6.60, 5.39, 4.23, and

4.47 per cent, which form close agreements with the corresponding samples in Table I.

17. The appearance of the two coals as received is shown in photographs, inclosures (E) and (F), and in inclosure (G) is indicated the separation of the Bering River coal into lump over seven-eighths inch, screenings through seven-eighths inch, and hand-picked slate, as well as the screen used. The Bering River coal has a luster and hardness closely resembling that of anthracite, does not break up readily, but shows a bright fracture when broken. The clean break closely resembles the reflecting surface of hard pitch and has no regular cleavage. The waste material can be readily distinguished from the good coal in luster, color, and shape of fragment. It is in the form of a carbonaceous shale of much higher specific gravity than the coal, the surface is dull, the color varies from dirty gray to dull black, and it always exists in the shape of flat lenticular fragments, whereas the good coal is irregular in size and shape. The specific gravity of the good coal as shown by displacement is 1.35, while that of the slate is 2.53.

18. The Pocahontas coal is characteristic of that field, dull, friable, containing in the run of mine about 35 per cent lump larger than seven-eighths inch. The fracture is along regular lines and the particles resulting are nearly cubical.

19. In order to determine the relative friability of the two coals, 10 lumps of each variety were selected for a drop test. The lumps which varied in size from 2.10 pounds to 27.71 pounds and measuring from 3 by 4 by 6 inches to 8 by 13 by 15 inches were dropped once from a platform 9 feet 10 inches high upon a concrete floor below. The fragments were separated into three sizes, viz, lump larger than 3½ inches, lump 3½ inches and over 4-mesh, and fines through 4-mesh. The results of these tests, which indicate clearly the ability of the two fuels to withstand breakage of lump upon handling, are as follows:

	Bering River.	Pocahontas.
Number of lumps in original sample	10	10
Number of broken lumps larger than 3½ inches	28	20
Lump larger than 3½ inches ... pounds	53.18	39.46
Lump through 3½ inches and over 4-mesh ... do	47.46	41.57
Screenings through 4-mesh ... do	6.19	13.04
Weight of original sample ... do	106.53	94.14
Lump larger than 3½ inches ... per cent	49.76	41.91
Lump through 3½ inches and over 4-mesh ... do	44.41	44.16
Screenings through 4-mesh ... do	5.83	13.93

The Pocahontas shows 2.39 times as much fine coal through 4-mesh as does the Bering River.

II. SCREENING PRELIMINARY TO WASHING.

20. The float and sink tests having shown the possibility of a great reduction in ash content by cleaning, it was at once decided to prepare the coal for evaporative test by a wet process, which, following the washery practice in the anthracite fields, required the separation of the coal into uniform sizes. The screens available were seven-eighths inch, one-half inch, 4-mesh, and 10-mesh, and from these a mechanically operated shaking screen was constructed and erected

as shown in photograph, inclosure (H). A variable-speed motor A drives a pulley B, on whose shaft is secured the disk crank C. The stroke may be from 4 to 10 inches, depending on which position the connecting rod D is secured. Coal is fed from the platform to the seven-eighths-inch screen E, which is 3 feet long, and the lump is delivered into the bin F in the foreground. The coal through seven-eighths-inch screen drops successively to the one-half-inch and 4-mesh screens G and H. These screens are 6 feet long and delivery is through chutes I. The 10-mesh screen L is 10 feet long, the slack falling through to a bin below and the screenings being delivered to the left. The screens are hung from a framework by one-fourth-inch cable to permit of adjustments of slope. The best pitch for efficient separation was found to be three-fourths of an inch per foot and the corresponding speed of the shaker was 110 revolutions per minute. The screening was done on October 2, 3, and 4, 1913, at the rate of about 4 tons per hour.

21. The coal weighed after screening showed the following proportions:

	Pounds.	Per cent.
Lump over ⅞ inch	19,577	25.38
Coal through ⅞ inch and over ½ inch	11,689	15.16
Coal through ½ inch and over 4-mesh	14,365	18.62
Coal through 4-mesh and over 10-mesh	15,819	20.51
Screenings through 10-mesh	15,682	20.33
Total	77,132	100.00

These results for the entire tonnage are in very close agreement with the 1-ton screening test, paragraph 9 which showed percentages of 25.59, 12.06, 17.39, 20.80, and 24.16 when the slate is eliminated.

III. WASHING OPERATIONS—DESCRIPTION OF PLANT.

22. Through the efforts of Mr. Chas. Enzian of the Bureau of Mines the station was offered the use of a 6-tons per hour basket type of jig manufactured by the Wilmot Engineering Co., of Hazleton, Pa., without charge except for the transportation of the machinery and the services of a competent man to oversee the erection and operation. Upon investigation these charges were found to be a large part of the quoted price of the machine, so that on November 7, 1913, a requisition for the purchase of a Wilmot Washer was made.

23. On November 25, 1913, the station was visited by Mr. G. R. Delamater, fuel engineer, formerly engineer in charge of the Denver washery plant of the Bureau of Mines. His report after an examination of the bins of screened Bering River coal was that a basket type of washery was entirely unsuited to coal of this character and containing the quality of slate associated therewith. Furthermore a jig with a capacity of 6 tons per hour would give a rate of washing too high for the small quantities of each size on hand (see paragraph 21), as too great a proportion of the fuel would be used in forming the bed in the basket and the washing would be so rapid that there would not be an opportunity of checking up the efficiency of the operation by the usual float and sink tests. Mr. Delamater thereupon prepared

sketches of a plunger type of jig with a capacity of 2 tons per hour, and from these sketches detailed drawings were made and a washery plant constructed at the station according to those plans after the requisition for the Wilmot jig had been canceled. The construction was begun on November 26, 1913, and completed on December 11, 1913, with the following costs:

Planning, estimating, and design	$50.61
Material	28.05
Labor	186.59
Total	265.25

24. The general layout of the washery plant is shown in drawing No. 484, and photograph, inclosure (J), and the details of the washing tank in drawing No. 485. When coal containing a considerable quantity of free slate or shale is placed in a vessel containing a solution of specific gravity higher than that of the particles of good coal, the slate will sink to the bottom and the combustible portions will remain on top. The imitation of this process on a large scale constitutes the working of an efficient washery. The principle utilized in the plunger type of jig is that a bed of conglomerate material will separate into layers of the same density when water is forced upward through the bed, the heavier particles seeking the bottom. The raw coal representing the conglomerate is fed onto a screen through which the water passes; the slate works its way to the bottom and is removed and the cleaned coal is carried off at the top with the overflow water. In addition soluble ingredients such as certain forms of organic sulphur often associated with coal are carried away, and clay and soft shale are broken up and washed out.

25. Referring to the general arrangement: A variable speed motor A drives through a jack shaft B the washer shaft C. The plunger P is driven through a connecting rod and a crank with variable throw and by its motion forces the water from the supply tank into the washing tank T and upward through the 16-mesh screen F. Coal is fed from the hopper D to the gate E, which regulates the feed to the screen. The slate and heavy materials that separate out pass under the gate G to the refuse bin M, from which the refuse is periodically drawn through the 4-inch quick-opening valve N, when the float indicator V rises to a predetermined point. The washed coal is carried by the overflow water down the chute H and onto the 10-mesh screen J. The water separates and flows away in the trench and the washed coal is discharged into barrows. The screen was driven by the same mechanism as was used in the sizing operations as described in paragraph 20. The hutch refuse which sifts through the 16-mesh screen into the tank may be drawn at the plug U. The details of the washery construction including connecting rod, plunger, and the arrangement for varying the length of plunger stroke, are shown in drawing No. 485. The hopper, refuse bin, and washery chamber are built up about a sheet-iron tank such as is used in weighing liquids. The plunger fits but loosely in its chamber, as the best results are obtained not by pumping the water through but by producing a tremor which agitates the bed to produce the desired separation. The usual practice in commercial operations is to use the water over again up to the point

where it becomes too highly charged with sludge, but in this test fresh water was used throughout, in order to obviate any delay which might be caused in constructing a suction tank, and the necessary circulating system. One feature in the design is subject to considerable improvement; that is, the method of removing the refuse. Before drawing down the refuse, the raw coal supply is shut off and after the flow of washed coal over the chute H ceases, the 4-inch valve is opened to draw the refuse down to a level indicated by the pointer. In so doing a quantity of the full bed is drawn under the gate G, as there are always pieces of coal below it to prevent proper seating. This results in somewhat more good coal going to the refuse pile than would be the case if the refuse were elevated and removed as fast as it worked past the refuse gate.

IV. OPERATION OF WASHERY.

26. The coal washing began on December 11, 1913, with the largest screened size seven-eighths to one-half inch, the washery being operated for the first day by Mr. G. R. Delamater. The raw coal to the feed hopper was sampled and weighed, the washed coal and refuse resulting therefrom was weighed and sampled, and the sizes of washed coal kept separate as before washing. One observer took samples for float and sink tests, which were made immediately, in order to serve as a guide to the operation of the jig. All float and sink tests were made with a zinc chloride solution of 1.65 specific gravity. A sample of about 5 pounds was selected for trial, emptied into a dish pan containing the solution, which was kept up to desired strength by the addition of fresh chemical as required. The float was skimmed off into a 40-mesh sieve and washed, the solution poured into another pan, and the sink fraction placed into a second sieve, where it was washed to rid it of accumulated zinc chloride. After the two fractions had drained for a few minutes, they were weighed and placed in cans to serve as samples for chemical analysis. The order of sampling was (1) raw coal, (2) washed coal, (3) refuse, (4) washed coal. and repeat, thus giving twice as many washed-coal samples as either raw coal or refuse. At the conclusion of the washing tests additional float and sink tests were made on a composite sample from the large can retained for chemical analyses. In the calculations the float and sink from the composite was given equal weight with the average of the separate determinations.

27. The experimental run of the washery was made with a length of stroke of 1 inch and a speed of 102 revolutions per minute. This did not result in sufficient agitation of the water to produce economical washing, so the length of stroke was increased to 2 inches and the speed kept practically constant. Trials with the smaller sizes showed that even better results were attained by increasing the speed to 128 revolutions per minute. The setting of the gate controlling the raw-coal feed was such as to give a slow feed of washed coal over the chute, and the height of the refuse gate was varied according to the size of coal being washed, so that the heavier slate particles would work under the gate without carrying over too great a proportion of good coal. Occasional samples drawn by hand from the bottom of the fuel bed on top of the 16-mesh screens served as an index to the proper setting of this gate, as too small a vent caused the refuse to accumulate on

the screen. The refuse was drawn as often as the float indicator V rose in its guide to a fixed point which marked the approximate filling of the refuse bin. No attempt was made to measure water consumed.

28. The float and sink tests of the washed coal, size one-half inch to 4-mesh, indicated that the washing of some of the coal had not been carried to the point of best ash reduction. Hence a portion of this coal was rewashed with considerable improvement. The refuse from the two larger sizes of coal, seven-eighths inch to one-half inch and one-half inch to 4-mesh, was rewashed and resulted in the salvage of about 50 per cent thereof of coal of good quality.

29. The results of the complete washery operations are given in Table III, Inclosure (N). The results indicate that with a small plant the three sizes washed, seven-eighths inch to one-half inch, one-half inch to 4-mesh and 4–10 mesh, may be reduced from dry ash contents in raw coal of 10.81, 12.88, and 18.43 per cent to washed coal with dry ash contents of 5.78, 6.79, and 11.66 per cent with the loss of refuse and good coal combined of 14.32, 27.41, and 19.80 per cent, giving ash reductions of 46.50, 47.28, and 36.72 per cent from the original. The excess loss in the middle size is due to the rewashing, so that with care the waste might have been 20 per cent as a maximum. Thus the result of hand cleaning, screening, and washing 76,634 pounds of coal, after deducting loss for sampling from the figures as given in paragraph 21, will produce the following:

Size.	Raw coal.	Dry cleaned coal.	Ash in cleaned coal.	B. t. u. per pound dry coal.
	Pounds.	*Pounds.*	*Per cent.*	
Lump over ⅞ inch	19,577	19,420	5.61	14,726
Coal through ⅞ inch and over ½ inch	11,559	9,791	5.78	14,756
Coal through ½ inch and over 4-mesh	14,170	10,183	6.79	14,557
Coal through 4-mesh and over 10-mesh	15,646	12,413	11.66	13,703
Dust through 10-mesh	15,682			
Total	76,634	51,807		

The combination of the several sizes, discarding the dust, which with 26.54 per cent ash in dry coal was pronounced unfit for use, would produce the following:

Size.	Total weight, dry coal.	Per cent of original weight.	Ash in dry coal.	B. t. u. per pound dry coal.
			Per cent.	
Over ⅞-inch	19,420	25.34	5.61	14,726
Over ½-inch	29,211	38.12	5.67	14,736
Over 4-mesh	39,394	51.41	5.96	14,690
Over 10-mesh	51,807	67.60	7.32	14,453

Based on quoted figures of $3 per ton for mining and $0.50 per ton for washing, the following would be the actual cost per ton of producing dry coal of the several sizes and qualities:

Lump over ⅞-inch	$12.34
Over ½-inch	8.37
Over 4-mesh	6.34
Over 10-mesh	4.96

30. It is noticeable in the summary of chemical analyses, Table II, that there is no appreciable reduction in the already low sulphur content, indicating the sulphur in this coal is entirely associated with the coal material and is not present in sulphur balls or pyrites. The refuse from the washery when wet is even more readily distinguishable from the good coal by the features mentioned in paragraph 17. The average fusing temperature of the float on 1.65 specific gravity, raw coal and washed coal are 2,459°, 2,361°, and 2,406° F., indicating that there would be only slightly less tendency for the washed coal to produce clinker than the raw coal, and that washing produces coal with a fusing temperature within approximately 40° of the raw coal and within 50° of the float on 1.65 specific gravity. The hutch refuse, of which 90 pounds were removed from the bottom of the washery tank, is the fine material which works its way through the bed screen. It is principally waste material, containing 30.59 per cent ash in dry coal. On an ash and moisture free basis the volatile matter is slightly lower in the float on 1.65 specific gravity than in the raw or washed coal, but the average carbon-hydrogen ratio for all sizes and treatments is almost exactly 20. The close agreement between the per cent of washed coal and refuse by weight and by analysis indicates that the utmost care was observed in sampling and analysis, but failure to agree with earlier analyses must be due to actual variations in quality, as the coal came from a number of workings. The general effect of washing and combining sizes over 10-mesh may be summarized:

(*t*) Loss in weight of raw coal as refuse, per cent	32.40
(*u*) Reduction in dry ash content, per cent	6.74
(*v*) Increase in heating value, B. t. u. per pound dry coal	1,167
(*w*) Increase in heating value, B. t. u. per pound coal ash and moisture free	93
(*x*) Increase in fusing temperature of ash, °F.	45
(*y*) Sulphur content	Unchanged.
(*z*) Carbon-hydrogen ratio	Unchanged.
(*zz*) Proportion of volatile matter	Unchanged.

31. Following instructions received from the bureau in its letter No. 112765–623–15 of December 15, 1913, such sizes were mixed as would produce a fuel of at most 6.8 per cent ash; there was rejected the washed coal size 4 to 10 mesh and a mixture made of screened, hand-picked lump over seven-eighths inch, washed nut seven-eighths inch to one-half inch, and washed pea coal one-half inch to 4 mesh, and it was with this mixture, together with about 1,800 pounds of rewashed refuse, that the evaporative tests were made.

V. EVAPORATIVE TESTS.

32. The evaporative tests were made on succeeding days, using first the Pocahontas run of mine coal and then the mixed Bering River coal. The duration of each test was exactly 24 hours, and all conditions within the control of the operating force were kept exactly the same. The first run was begun December 16, 1913, at 12 noon, and concluded December 17, 1913. The Bering River test began at 8 p. m. of the same day, the slight delay in starting being due to time necessary to repair certain leaks that appeared after the boiler was cool.

33. The evaporative power of the two fuels was determined by weighing the coal as fired and the water fed to a marine water-tube boiler. A portion of the steam generated was utilized to operate test and station auxiliaries, but a large portion thereof was condensed and weighed back to the hot well, whence the feed pump took its suction. Steam pressure was maintained constant at 300 pounds gauge by varying the amount of steam bled to the condenser.

34. The boiler with which the tests were conducted is of the Babcock & Wilcox marine type, with the following principal dimensions:

Diameter of steam drum, 31¾ inches.
Length of steam drum, 9 feet 11½ inches.
Number of 4-inch tubes, 16.
Number of 2-inch tubes, 407.
Thickness of 4-inch tubes, B. W. G. No. 6.
Thickness of 2-inch tubes, B. W. G. No. 8.
Length of 4-inch tubes, 7 feet 6 inches.
Length of 2-inch tubes, 403 at 9 feet, 4 at 8 feet 6 inches.
Furnace length, 7 feet.
Furnace width, 8 feet 4 inches.
Height at front, 25 inches.
Height at rear, 41 inches.
Length of grate, 7 feet.
Width of grate, 8 feet 4 inches.
Area of grate surface, 58⅓ square feet.
Area of heating surface, 2,161 square feet.
Ratio—heating surface: Grate surface, 37.1.
Per cent water heating surface, 100.
Per cent superheating surface, 0.
Kind of grate bars, Navy standard, single, cast iron.
Width of air spaces, ⅝ by 32 inches.
Total area of air spaces, 24.5 square feet.
Ratio—air space: Grate area, 0.42.
Volume of furnace, 160 cubic feet.
Ratio—furnace volume: Grate area, 2.74.
Area of smoke pipe, 8.72 square feet.
Height of smoke pipe above grate, 68 feet.
Ratio—grate area: Smoke pipe area, 6.69.
Water space, 117 cubic feet.
Steam space, 24 cubic feet.
Weight of water in boiler at 120° F., 7,250 pounds.
Draft by steam jet in stack.
Feed heater, Blake vertical.
Feed pump, Boston Navy Yard design.
Dimensions of cylinders, 16 by 10 by 12 inches.

35. The coal was wheeled from the bin to the boiler room in barrows each holding about 300 pounds of coal. A part of a shovel full was selected at random to give correct proportion of lump and fine coal, stowed in a can with close-fitting top, and the barrow weighed on platform scales to the nearest one-half pound. After dumping the coal upon the fireroom floor the empty barrow was weighed. At the end of every hour during the run, the coal upon the floor was weighed back to obtain the hourly totals of coal fired.

36. The ash pit was cleaned at the end of each hour and the ash collected was weighed and sampled. The ashes were not wetted down before weighing, though enough water was put into the ash pit to keep the bottom from blistering. All water to the pit was metered. The clinkers removed from the furnace were wetted down enough to be handled comfortably, weighed, and sampled. At the conclusion of the run the clinker adhering to the bridge wall and the soot accu-

mulating on tubes and baffles was removed, weighed, and sampled. All samples were crushed and quartered, reduced to 3-pound can size and forwarded to the Bureau of Mines, Pittsburgh, Pa., for analysis.

37. The feed pump drew its suction from a hot well from which all other pumps were blanked off, and the water to the hot well was weighed in 2,000-pound tanks mounted above. The steam generated by the boiler was condensed and pumped to these tanks and make-up feed was drawn from a reserve supply as required and weighed in tanks of 400 pounds net capacity. The hot well is a concrete tank with a level correction of 410 pounds per inch of height, and the hourly weights of water fed were corrected according to the variation as shown by a float on the tank.

38. The barometer reading to the nearest one-hundredth inch was recorded hourly, the temperature of the column being noted in order to reduce the reading to 32° F. The steam pressure at the boiler was taken to the nearest one-half pound per square inch by an accurate 1-pound interval test gauge attached to the safety valve nozzle. The pressure within the calorimeter was taken by a gauge which could be read to one-tenth of a pound. The draft in furnace and at base of stack were measured by inclined glass tube gauges graduated to read one-hundredth inches of water. Recording gauges were also coupled at the same points.

39. Mercury-in-glass thermometers were employed to obtain temperatures of external air, fireroom, feed water and steam in the steam line and in the calorimeter. The two latter had attached stem thermometers to correct for the stem exposure. Thermocouples were inserted in the back of the furnace and at the base of the stack to obtain the temperatures of the gases of combustion at those points. The latter was also measured by a high-reading nitrogen-filled mercury-in-glass thermometer suitably baffled to prevent radiation to adjacent metal surfaces.

40. The wind direction and velocity were shown by a wind vane and a wind gauge, respectively. To obtain the humidity of the atmosphere readings were taken of a dew-point hygrometer and a wet-bulb thermometer. A plentiful circulation of air past the wet bulb was maintained by an electric fan.

41. A sampling tube was inserted in a vertical portion of the steam pipe about 2 feet from the stop valve attached directly to a nozzle on the boiler drum. A throttling calorimeter with the necessary pressure gauge and thermometers was attached thereto. The smoke density was observed by comparisons during daylight with a Ringelmann's smoke chart obtained from the Bureau of Mines.

42. Samples of the flue gases were taken from the first pass of the gases across the tubes and from the base of the stack. To obtain the former, a one-half inch wrought-iron pipe with one end capped and containing 10 one-sixteenth inch holes was inserted into the lowest peephole of the aft-side cleaning door and extended nearly to the far side of the boiler. The stack sample was obtained through a spider consisting of a cast-iron body and six legs of one-half inch wrought-iron pipe with capped ends and a narrow slit along the under side of each. Flow of gases to the sample containers was produced by a steam ejector. The actual sample collected by mercury displacement in a 250 c. c. holder was taken from the stream of gas each half hour,

the flow of mercury being hand adjusted to fill the container in this period of time.

43. Before the test the boiler was carefully cleaned of mud and soot. No leaks were apparent under a water pressure of 450 pounds. At the conclusion of the first test—that on Pocahontas coal—a leak was noted at the lowest nipple on right front header. All the water was drained out of the boiler and this nipple rolled in, after which the boiler was filled with hot water and the fires lighted off for the second test.

44. The duration of each test was 24 hours, and the detail of firemen, water tenders, and observers was the same for each test, so that item was eliminated as far as possible. The fires were built up and after the boiler had begun to steam the draft was put on and full load carried. After an hour or more, when the setting had attained a uniform temperature, the test proper was begun by carefully leveling off all fires, firing lightly for 10 or 20 minutes to maintain this level, and observing as accurately as is possible on an incandescent bed the thickness of the fires at the signal of the next succeeding hour. This marked the exact beginning of the test, and from this time on all observations were taken at 15-minute intervals, except weights of water and coal, as before noted. Twenty-three hours thereafter such furnaces as required were cleaned and the fires gradually burned down to the level of the preceding day, allowing, again, about 20 minutes before the final signal for a period of alternate leveling and light firing to reproduce conditions at the beginning of the test. By this means it was possible to reduce the uncertainty of difference in height of fires at beginning and end of test to 2 inches or less, which, with a grate area of 58⅓ square feet, makes the maximum possible error in coal weights 300 pounds, about 1 per cent of the total.

45. A firing interval of five minutes between the times of coaling any one of the three furnace doors was selected. A time firing device, consisting of a variable speed motor, geared down to drive an interrupter disk with one, two, and three contacts at a speed of one revolution in five minutes, was used. The interrupter was in circuit with a flash lamp mounted within view of the firemen, and the number of flashes as produced by the interrupter closing the circuit for one, two, or three short intervals indicated the door to be coaled The coal was spread over the fuel bed, and after coaling any one door the fire in the door next to be coaled was leveled. The slice and pricker bars were used only when necessary to clear the grates if the ash pit became dark, no breaking up of fires being allowed. The thickness of fires varied slightly, as it was desired to maintain a flue gas analysis of 12 per cent CO_2 while not exceeding 1 per cent CO, and the fires were accordingly adjusted to obtain these figures. The fire in each door was cleaned once in 12 hours.

46. In addition to the quantities regulated as explained above, the draft at the base of the stack was maintained at three-fourths inch of water by hand adjustment of the steam jet in the stack; the feed temperature was regulated from 180° to 190° F.; the steam pressure was kept at 300 pounds per square inch by bleeding to the condenser; the water level in the boiler was kept within 2 inches of the bottom of the gauge glass; and the water level in the hot well was

high enough that the suction to the feed pump was fully covered at all times. All instruments were carefully calibrated.

VI. RESULTS OF EVAPORATIVE TESTS.

47. The general results of the evaporative tests are given in Table IV, inclosure (O), the analyses of samples of coal, ash, clinker and soot in Bureau of Mines laboratory reports, inclosure (P), and the records of boiler pressure, feed temperature, and stack draft in reproductions, inclosures (R), (S), and (T). The photographs in inclosures (Q-1) and (Q-2) show the density of the smoke at the stack in the foreground between coaling periods and when coaling furnaces.

48. The Pocahontas coal burns readily with little clinker and clean ash, yielding with a 7.4-inch fire stack gases with 12.74 per cent CO_2 and 1.12 per cent CO. The clinker is readily broken up and does not adhere to the grate bars, so that no difficulty was encountered in maintaining full boiler pressure and obtaining the average rate of evaporation even during the period when the fires were burning down preliminary to cleaning. By reference to the pressure-gauge records, in which the cleaning operations are indicated by "C. F.," followed by the number of the fire door cleaned, it is noted that the only time that there was a noticeable drop in pressure was at 10.10 p. m., when the pressure fell for an instant to 235 pounds. but quickly returned to normal. The minimum evaporation for any one hour was 12,063 pounds of water, whereas the maximum was 14,752 pounds.

49. The Bering River coal when first fired on a clean grate burns with a fierce fire and produces a high evaporation. Gradually, however, a dense clinker forms which fuses to the grate bars, filling the air spaces and preventing the entrance of sufficient air for combustion. During the first hour the evaporation was 14,872 pounds of water and 1,814 pounds of coal were burned. In three hours the hourly evaporation had fallen to 10,731 pounds and the corresponding coal consumption was 1,263 pounds. From that time, although the greatest effort was made to break up this clinker by slicing through the fire door and driving a sharpened pricker bar between the grate bars from the ash pit below, the evaporation remained low. The minimum rate was 7,114 pounds per hour and the maximum 11,113, the corresponding coal consumption being 660 pounds and 1,159 pounds. Not only during cleaning periods, but frequently between times, it was impossible to maintain boiler pressure with the bleeder closed and with the boiler generating only steam required for auxiliaries and station turbo-electric unit on lighting load.

50. Following a cleaning period the ash pit below the grate cleaned remains bright for about 20 minutes, during which time some of the ashes formed drop through. Thereafter as the clinker again fuses in a mass over the grate and between the air spaces, the ash is retained in the furnace until the next cleaning and the furnace draft is so reduced as to further reduce the rate of combustion. Had it not been for the fairly high rate of evaporation during the first three hours, when all furnaces were bright and clean, the hourly evaporation would have been less than 10,000 pounds.

51. The following notes are transcribed from records made during the test:

During the preliminary test (7 to 8 p. m., Dec. 17, 1913) considerable ash dropped through the grate. Fire is burning fiercely. As coal burns down clinker formed on grate and prevented further dropping. Firemen can not break clinker, as all is fused into one mass. Grates getting black at 9.30 p. m. Fire is about 5 inches thick. First cleaning at 10.10 p. m. A thin bed of clinker is tightly fused to bars and spaces between. Ash pit under furnace being cleaned is black. Pricker bar used to open spaces from below. Time of cleaning, 10 minutes; steam pressure dropped to 255 pounds.

And further, on December 18:

Cleaning middle door at 6.10 a. m. This fire has gone 11 hours without cleaning. Two inches of hard clinker is on grates. Pressure dropped to 228 pounds. Time of cleaning, 10 minutes; grate and pit fairly bright after cleaning.

52. No coke is formed during combustion, each lump appearing to burn as a unit instead of uniting with adjacent ones to form a coke mass after the distillation of gases. Flue gas analysis with 7.29-inch fires shows 10.97 per cent CO_2 and 0.53 per cent CO. By reference to inclosures Q1 and Q2 it is seen that smoke is considerably lighter with Bering River than with Pocahontas. The average by the Ringelmann chart is 59.4 per cent for Pocahontas and 27.4 per cent for Bering River. The difference is in part due to much lower rate of driving. The logs indicated the use of the slice and pricker bars 65 times during the Pocahontas trial and 153 times during the test of Bering River coal. This is in addition to fire cleaning.

VII. SUMMARY.

53. The main points which stand out from a comparison of the results in Table IV are as follows: The general conditions of temperatures and pressures were very constant for both tests with the exception of furnace draft, furnace and stack temperatures. The drop through the fuel bed was higher with the Bering River coal than with Pocahontas, since the accumulation of clinker and ash produced a greater resistance. On account of more rapid combustion and less air dilution the furnace and stack temperatures were higher for Pocahontas coal. With 0.75 inch draft at the base of the stack, a combustion of 34,893 pounds of dry Pocahontas coal on a 58½ square foot grate in 24 hours was obtained without difficulty, but it required considerable urging to enable the firemen to burn 26,731 pounds of dry Bering River coal in the same time. The percentage of refuse in the two cases was not far different, but it was divided very differently. With Pocahontas coal, twice as much ash falls through the grate as is removed from the furnace in the way of clinker and ash at cleaning periods. With Bering River coal, the accumulation within the furnace is far greater than the ash dropping through.

54. The coals are very similar chemically, the screening and cleaning of the Bering River coal having produced a slightly lower ash content and higher heating value than that of the Pocahontas. The coal consumed per square foot of grate per hour is 24.95 and 19.11, or 1.3 as much Pocahontas as Bering River. A deeper fire and heavier draft would have produced possibly an even higher rate of combustion of Pocahontas coal with higher CO in stack gasses and lower boiler efficiency, but the 19.11 pounds for the Bering River is an absolute maximum, which no amount of forcing could have increased appreciably because of the mass of clinker on the grates. The total actual evaporation for the two tests was 324,355 and

242,908 pounds, corresponding to 350,272 and 261,231 pounds equivalent, or hourly rates actual of 13,451 and 10,075 pounds and equivalent from and at 212° F. of 14,595 and 10,885 pounds. The Pocahontas coal gave a rating of 422.9, as against 315.5 boiler horsepower for the Bering River, or 1.34 times as much.

55. The Pocahontas coal shows only slightly better evaporation per pound of fuel than the Bering River, but it must be borne in mind that the boiler with the domestic fuel was being forced to a greater capacity, and, everything else being equal, should show slightly lower economic results. The boiler efficiency on both a dry coal and combustible basis is almost exactly 2 per cent higher for Pocahontas coal. The stack gasses show a considerable difference in composition because of the great excess air admitted in the test of the Bering River coal. An important difference is shown by the water put in the ash pit. With Pocahontas coal, a total of 1,612 pounds sufficed to keep the pit reasonably cool and prevent chipping of the concrete lining, but with Bering River coal it was necessary to place 3,886 pounds in the pit during the progress of the test, and even then the concrete broke badly. Not only was the heat radiated greater, but there was seldom the protecting coating of ashes which fell through the grates with considerable uniformity as the Pocahontas coal burned down.

56. The heat balance, items 115 to 133, shows the distribution of losses. It involves, however, no very noteworthy features, except that the total stack loss for the two coals was about the same. That is, any saving in reduction of CO loss on the part of the Bering River coal is entirely made up by the additional loss on account of dilution of stack gases. The fusing temperatures of the ash from the four samples of coal, inclosures P1, P2, P7, and P8, are again not consistent with the performance of the fuels in the furnace. The Pocahontas coal shows on the average an ash fusing temperature of 2,438° F., while the Bering River has the value 2,492° F., a value higher than that obtained on any single sample from the screening or washing operations. The only sample having anything like so high a fusing temperature is the float on 1.65 specific gravity, one-half inch to 4-mesh, inclosure L6, which shows 2,489° F. A satisfactory index for the tendency of clinker to form on a grate must, it appears, involve a great many factors other than the fusing point of ash.

57. Samples of clinker from the two tests and raw shale from Bering River coal were analyzed at the station, showing the following carbon-free composition:

Sample.	Pocahontas coal.		Bering River coal.		
	Clinker from grate.	Clinker from bridge wall.	Clinker from grate.	Clinker from bridge wall.	Raw shale.
SiO_2	57.59	52.15	43.29	41.46	27.42
Fe_2O_3	14.86	18.68	16.36	22.64	6.35
Al_2O_3	18.04	18.60	22.24	22.66	13.55
Mn_3O_4	2.00	2.00	2.13	....	....
CaO	3.73	5.00	10.64	10.47	40.17
$CaSO_4$	1.04	1.04	1.00	.56	5.42
MgO	1.00	.89	2.23	2.30	2.94
K_2O	1.95	1.48	2.27	Trace	4.00

The silica, which is the only acid constituent, is in excess of the basic and neutral elements in the clinker from both coals, but the excess is greater for the Pocahontas. Most of the bases, which when existing alone are quite infusible, produce when combined with the other basic elements here present and with silica a cinder of lower fusing point than any of the constituents. Although these analyses show a separation into oxides and the neutral calcium sulphate, the mass actually exists as a complex combination in which the original properties of the constituents are entirely changed, and while the chemical analyses show a considerable difference in the silica, iron, alumina, and lime content, it can not with any certainty be said in how far these contribute to the marked difference in behavior of the coal on the grates.

VIII. RECOMMENDATION.

58. In spite of all the refinements of cleaning and washing, which reduced the ash content of dry Bering River coal from 14.06 as received to 5.42 in the dry coal actually fired, involving in the preparation a loss of 48.59 per cent of the fuel as mined, the highest obtainable rate of evaporation was 5.04 pounds of water from and at 212° F. per square foot of water heating surface and a combustion of 19.11 pounds of dry coal per square foot of grate surface per hour. Since the operation of the type of boiler on which these tests were conducted to meet full speed conditions in the service requires under somewhat greater draft the evaporation of at least 8 pounds of water per square foot of heating surface and a coal consumption of more than 30 pounds per square foot of grate surface per hour, it appears that Bering River coal is entirely unsuited to the needs of the service as a steam coal, and it is not recommended for use on standard Navy grate bars. Incidentally the cost of preparation even on a large scale would be $6.34 per ton cleaned coal, so that, overlooking the difference in evaporative power, it would still not compete with eastern bituminous coals shipped to the west coast.

LEO LOEB.

APPENDIX I.

Method of obtaining items in Table III.

Item.
1. For reference.
2, 3, 4. Observed.
5. As weighed.
6. $\frac{\text{Item 5}}{\text{Item 4}}$.
7, 8. As weighed.
9, 10, 11. From Bureau of Mines coal analyses, inclosure (L).
12. $\frac{\text{Item 5 }(100-\text{item 9})}{100}$.
13. $\frac{\text{Item 7 }(100-\text{item 10})}{100}$.
14. $\frac{\text{Item 8 }(100-\text{item 11})}{100}$.

15. Item 12 − (item 13 + item 14).

16, 17, 18, 19, 20, 21. From float and sink tests as noted in paragraph 26.

22, 23, 24, 25, 26. From Bureau of Mines coal analyses, inclosure (L).

27. $\frac{\text{Item 24} - \text{item 25}}{\text{Item 24}} \times 100.$

28. $\frac{\text{Item 13}}{\text{Item 12}} \times 100.$

29. 100 − item 28.

30. $\frac{\text{Item 26} - \text{item 24}}{\text{Item 26} - \text{item 25}} \times 100.$

31. $\frac{\text{Item 24} - \text{item 25}}{\text{Item 26} - \text{item 25}} \times 100.$

32. $\frac{\text{Item 31} \times \text{item 26}}{\text{Item 24}} \times 100.$

33. $\frac{(\text{Item 16} \times \text{item 22}) + (\text{item 17} \times \text{item 23}).}{100}$

APPENDIX II.

REPORT OF COMPARATIVE EVAPORATIVE TEST POCAHONTAS AND BERING RIVER, ALASKA, COAL.

Method of obtaining items in Table IV.

Item.
1, 2, 3, 4. For reference.
5. From data corrected for temperature according to Smithsonian Meteorological Tables.
6. Item 5 × 0.491.
7. Observed.
8. Item 7 + item 6.
9. Observed.
10, 11. From readings of differential draft gages.
12, 13, 14. Observed.
15. From steam tables corresponding to pressure in item 8.
16. Observed.
17, 18. From thermo-couple observations.
19. Observed.
20, 21. Observed.
22. From recording anemometer.
23, 24. Observed.
25. From Weather Bureau tables corresponding to items 13 and 23.
26. Calculated from density of dry, saturated steam corresponding to items 13 and 24.
27. Average of items 25 and 26.
28. Item 27 × density of dry, saturated steam corresponding to item 13.
29. From formula for the density of dry air:

$$M = \frac{pV}{RT}$$

where M = weight in pounds of 1 cubic foot = item 29.
p = pressure of dry atmosphere in pounds per square foot = 144 [item 6 − (pressure corresponding to item 13 × item 27)].
R = a constant, for air . . . 53.35.
T = absolute air temperature = 459.6 + item 13.

30, 31. For reference.
32. As weighed during test.
33. From Bureau of Mines coal analyses, inclosure (P).

34. Item 32 $\times \frac{(100 - \text{item } 33)}{100}$.

35, 36, 37, 38. As weighed corrected for moisture by analysis.
39. Item 35 + item 36 + item 37 + item 38.
40. Item 34 − item 39.

41. $\frac{\text{Item } 35 + \text{item } 36 + \text{item } 37}{\text{Item } 34} \times 100$.

42–52. From Bureau of Mines coal analyses, inclosure P.

53. $\frac{\text{Item } 42}{100 - \text{item } 42} \times 100$.

54–70. From Bureau of Mines analyses, inclosure P.

71. $\frac{\text{Item } 34}{24}$.

72. $\frac{\text{Item } 40}{24}$.

73. $\frac{\text{Item } 71}{58\frac{1}{3}}$.

74. $\frac{\text{Item } 72}{58\frac{1}{3}}$.

75, 76. Observed.
77. From formula—
x=quality in per cent dryness=item 77.

$$x = \frac{H_e + c_p\,(t_s - t_e) - q_b}{r_b} \times 100.$$

H_e=total heat of dry saturated steam corresponding to (item 76+item 6).
c_p=mean specific heat of superheated steam at calorimeter pressure.
t_s=temperature within calorimeter=item 75.
t_e=temperature corresponding to calorimeter pressure (item 76+item 6).
q_b=heat of liquid corresponding to boiler pressure, item 8.
r_b=heat of vaporization corresponding to boiler pressure, item 8.
78. 100−item 77.
79. From formula—
$H = q_b + r_b - q_f$
where H=heat in dry saturated steam above feed temperature=item 79.
q_b and r_b as above.
q_f=heat of the liquid corresponding to feed temperature, item 16.
80. From formula—
$H = q_b + x r_b - q_f$
where H=heat in wet steam above feed temperature=item 80.
q_b, r_b and q_f as above.
x=item 77.

81. $\frac{\text{Item } 80}{\text{Item } 79}$.

82. $\frac{\text{Item 79}}{970.4}$.

83. As weighed.
84. Item 83×item 81.
85. Item 84×item 82.

86. $\frac{\text{Item 84}}{24}$.

87. $\frac{\text{Item 85}}{24}$.

88. $\frac{\text{Item 87}}{2161}$.

89. $\frac{\text{Item 87}}{34.5}$.

90. Based on 10 square feet of heating surface per boiler horsepower.

91. $\frac{\text{Item 89}}{\text{Item 90}}$.

92. $\frac{\text{Item 83}}{\text{Item 32}}$.

93. $\frac{\text{Item 84}}{\text{Item 34}}$ or $\frac{\text{item 86}}{\text{item 71}}$.

94. $\frac{\text{Item 85}}{\text{Item 32}}$.

95. $\frac{\text{Item 85}}{\text{Item 34}}$ or $\frac{\text{item 87}}{\text{item 71}}$.

96. $\frac{\text{Item 85}}{\text{Item 40}}$ or $\frac{\text{item 87}}{\text{item 72}}$.

97. $\frac{\text{Item 95}\times 970.4}{\text{Item 67}}\times 100$.

98. $\frac{\text{Item 96}\times 970.4}{\text{Item 68}}\times 100$.

99. From observations during daylight.
100–108. From analysis of pass and stack gas samples collected each half hour.
109. As weighed.
110. From ash analysis, inclosure P.
111. Item 109−item 110.
112. Quantity of air containing oxygen (0.232 parts by weight) to burn coal as per items 47 to 51 to flue gases of composition as per proportions of CO_2 and CO in items 105 and 107.
113. Quantity of air containing oxygen (0.232 parts by weight) to burn coal as per items 47 to 51 and produce flue gases as per items 105 to 108.

114. $\frac{\text{Item 113}-\text{item 112}}{\text{Item 112}}\times 100$.

115. Item 95×970.4.
116. Item 42×H—
where H is heat required to vaporize moisture from a temperature of item 13 to superheated steam at a temperature of items 18 and 19.

117. Item 48×9×H—
where H is as above.

118. Item 113×c_p×(Item 18−item 13)—
where c_p is the mean specific heat of the products of combustion over the rise in temperature.

119. 10170×pounds of carbon per pound of coal burned to CO.

120. $\frac{14544}{\text{Item } 34}\times\frac{1}{100}$ (Item 35×item 59+item 36×item 61+item 37×item 63 +item 38×item 65).

121. $\frac{\text{Item } 28\times\text{item } 113\times(\text{item } 18-\text{item } 13)\times c_p}{\text{Item } 29},$

where c_p is the mean specific heat of water vapor over the range item 13 to item 18.

122. Item 111×H, where H is as in item 116.

123. Item 67−(item 115+item 116+item 117+item 118+item 119+item 120+item 121+item 122).

124. Item 67.

125. Item 96×970.4.

126. $\frac{\text{Item } 116\times\text{item } 34}{\text{Item } 40}.$

127. $\frac{\text{Item } 117\times\text{item } 34}{\text{Item } 40}.$

128. $\frac{\text{Item } 118\times\text{item } 34}{\text{Item } 40}.$

129. $\frac{\text{Item } 119\times\text{item } 34}{\text{Item } 40}.$

130. $\frac{\text{Item } 121\times\text{item } 34}{\text{Item } 40}.$

131. $\frac{\text{Item } 122\times\text{item } 34}{\text{Item } 40}.$

132. Item 68−(item 125+item 126+item 127+item 128+item 129+item 130+item 131).

133. Item 68.

BUREAU OF MINES—COAL ANALYSIS REPORTS.

[By A. C. Fieldner, Chemist.]

INCLOSURE A1.

Laboratory No. 17736. Can No. 55445 (A7).
Sample of coal (Bering River).
From United States Naval Academy.
State, Maryland.
Town, Annapolis (Engineering Experiment Station).
Method of sampling (as received, not screened or cleaned).
Date of sampling, September 20, 1913. Date of analysis, September 30, 1913.
Collector, Charles Enzian.

[Air-dry loss, 1.2.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.88	2.11	....	....
Volatile matter	16.22	16.02	16.37	19.05
Fixed carbon	68.97	68.11	69.57	80.95
Ash	13.93	13.76	14.06	....
	100.00	100.00	100.00	100.00
Ultimate analysis:				
Hydrogen	4.14	4.23	4.09	4.76
Carbon	76.14	75.20	76.82	89.39
Nitrogen	1.52	1.50	1.53	1.78
Oxygen	3.57	4.62	2.80	3.26
Sulphur	.70	.69	.70	.81
Ash	13.93	13.76	14.06	....
	100.00	100.00	100.00	100.00
Calorific value determined:				
Calories	7,316	7,225	7,381	8,589
B. t. u	13,169	13,005	13,286	15,460
Calorific value calculated from ultimate analysis:				
Calories	....	7,349	....	....
B. t. u	....	13,228	....	....

Real specific gravity, 1.43.
Fusing temperature of ash (in reducing atmosphere in molybdenum furnace) 1,271°C=2320°F.
October 2, 1913.

INCLOSURE A2.

Laboratory No. 17741. Can No. 55459(A2).
Sample of coal (Bering River).
State, Maryland; county, Anne Arundel.
Town, United States Naval Academy Engineering Experiment Station, Annapolis, Md..
Method of sampling: Over seven-eighths-inch mesh; hand-picked; quartered.
Date of sampling, September 19, 1913. Date of laboratory sampling, September 25. Date of analysis, September 30.
Collector, Charles Enzian.

[Air-dry loss 0.4.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.44	0.80	....	....
Volatile matter	18.47	18.40	18.55	19.65
Fixed carbon	75.51	75.24	75.84	80.35
Ash	5.58	5.56	5.61	....
	100.00	100.00	100.00	100.00
Ultimate analysis:				
Hydrogen	4.40	4.42	4.37	4.63
Carbon	84.55	84.25	84.93	89.97
Nitrogen	1.62	1.61	1.62	1.72
Oxygen	3.17	3.48	2.78	2.95
Sulphur	.68	.68	.69	.73
Ash	5.58	5.56	5.61	....
	100.00	100.00	100.00	100.00
Calorific value determined:				
Calories	8,144	8,115	8,181	8.667
B. t. u	14,659	14,607	14,726	15,601
Calorific value calculated from ultimate analysis:				
Calories	....	8,194	....	....
B. t. u	....	14,749	....	....

Fusing temperature of ash (in reducing atmosphere in molybdenum furnace): 1,263° C.=2,305° F.
October 1, 1913.

INCLOSURE A3.

Laboratory No. 17742. Can No. 55377 (A3).
Sample of coal (Bering River).
State, Maryland.
Town, United States Naval Academy, Engineering Experiment Station, Annapolis, Md.
Method of sampling: Screenings through seven-eighths inch and over one-half inch; quartered.
Date of sampling, September 19, 1913. Date of laboratory sampling, September 25. Date of analysis, September 30.
Collector, Charles Enzian.

[Air-dry loss, 0.5.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.49	0.97		
Volatile matter	17.37	17.29	17.46	20.02
Fixed carbon	69.44	69.10	69.77	79.98
Ash	12.70	12.64	12.77	
	100.00	100.00	100.00	100.00
Ultimate analysis:				
Hydrogen	4.21	4.24	4.17	4.78
Carbon	77.58	77.21	77.97	89.38
Nitrogen	1.56	1.55	1.57	1.80
Oxygen	3.28	3.69	2.84	3.26
Sulphur	.67	.67	.68	.78
Ash	12.70	12.64	12.77	
	100.00	100.00	100.00	100.00
Calorific value determined:				
Calories	7,460	7,424	7,497	8,595
B. t. u	13,428	13,363	13,495	15,471
Calorific value calculated from ultimate analysis:				
Calories		7,556		
B. t. u		13,601		

Fusing temperature of ash (in reducing atmosphere in molybdenum furnace): 1,227° C.=2,241° F. Sp. gr. 1.45.

October 1, 1913.

INCLOSURE A4.

Laboratory No. 17734. Can No. 55376 (A4).
Sample of coal (Bering River).
From United States Naval Academy.
State, Maryland.
Town, Annapolis (Engineering Experiment Station).
Method of sampling: Screening through one-half inch and over No. 4 mesh; quartered.
Date of sampling, September 19, 1913. Date of analysis, September 30, 1913.
Collector, Charles Enzian.

[Air-dry loss, 0.5.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.85	1.37		
Volatile matter	16.18	16.10	16.32	19.54
Fixed carbon	66.62	66.27	67.19	80.46
Ash	16.35	16.26	16.49	
	100.00	100.00	100.00	100.00
Ultimate analysis:				
Hydrogen	4.00	4.04	3.94	4.72
Carbon	73.89	73.51	74.53	89.25
Nitrogen	1.51	1.50	1.52	1.82
Oxygen	3.57	4.01	2.83	3.38
Sulphur	.68	.68	.69	.83
Ash	16.35	16.26	16.49	
	100.00	100.00	100.00	100.00
Calorific value determined:				
Calories	7,119	7,082	7,180	8,598
B. t. u	12,814	12,748	12,924	15,476
Calorific value calculated from ultimate analysis:				
Calories		7,175		
B. t. u		12,915		

Fusing temperature of ash (in reducing atmosphere in molybdenum furnace), 1,255° C.=22,91° F.

October 2, 1913.

INCLOSURE A5.

Laboratory No. 17737. Can No. 55380 (A5).
Sample of coal (Bering River).
From United States Naval Academy.
State, Maryland.
Town, Annapolis (Engineering Experiment Station).
Method of sampling: Screening through No. 4 and over 10 mesh.
Date of sampling, September 19, 1913. Date of analysis, September 30, 1913.
Collector, Charles Enzian.

[Air-dry loss, 0.6.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.90	1.50	....	....
Volatile matter	15.64	15.54	15.78	19.19
Fixed carbon	65.86	65.47	66.46	80.81
Ash	17.60	17.49	17.76	....
	100.00	100.00	100.00	100.00
Ultimate analysis:				
Hydrogen	4.04	4.09	3.98	4.84
Carbon	72.38	71.94	73.03	88.80
Nitrogen	1.52	1.51	1.53	1.86
Oxygen	3.77	4.28	3.00	3.65
Sulphur	.69	.69	.70	.85
Ash	17.60	17.49	17.76	....
	100.00	100.00	100.00	100.00
Calorific value determined:				
Calories	6,994	6,951	7,057	8,581
B. t. u	12,589	12,512	12,703	15,446
Calorific value calculated from ultimate analysis:				
Calories	....	7,052	....	....
B. t. u	....	12.694	....	....

Fusing temperature of ash (in reducing atmosphere in molybdenum furnace), 1,248° C.=2,278° F. October 1, 1913.

INCLOSURE A6.

Laboratory No. 17735. Can No. 55381 (A6).
Sample of coal (Bering River).
From United States Naval Academy.
State, Maryland.
Town, Annapolis (Engineering Experiment Station).
Method of sampling: Screening through No. 10-mesh screen; not cleaned.
Date of sampling, September 20, 1913.
Date of analysis, September 30, 1913.
Collector, Charles Enzian.

[Air-dry loss, 0.9.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	1.10	2.03	....	....
Volatile matter	15.06	14.92	15.23	20.73
Fixed carbon	57.59	57.05	58.23	79.27
Ash	26.25	26.00	26.54	....
	100.00	100.00	100.00	100.00
Ultimate analysis:				
Hydrogen	3.63	3.70	3.54	4.82
Carbon	63.77	63.17	64.48	87.78
Nitrogen	1.37	1.36	1.39	1.89
Oxygen	4.37	5.17	3.44	4.68
Sulphur	.61	.60	.61	.83
Ash	26.25	26.00	26.54	....
	100.00	100.00	100.00	100.00
Calorific value determined:				
Calories	6,137	6,079	6,205	8,447
B. t. u	11,047	10,942	11,169	15,205
Calorific value calculated from ultimate analysis:				
Calories	....	6,169	....	....
B. t. u	....	11,104	....	....

Fusing temperature of ash (in reducing atmosphere in molybdenum furnace): 1,331° C.=2,428° F. October 2, 1913.

INCLOSURE A7.

Laboratory No. 17738. Can No. 55387 (A1).
Sample of coal (Bering River).
From United States Naval Academy.
State, Maryland. County, Anne Arundel.
Town, Annapolis (Engineering Experiment Station).
Method of sampling: Screenings through seven-eighths inch mesh; quartered.
Date of sampling, September 18, 1913. Date of analysis, September 30, 1913.
Collector, Charles Enzian.

[Air-dry loss, 0.9.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.88	1.72		
Volatile matter	16.37	16.23	16.51	20.12
Fixed carbon	64.97	64.42	65.55	79.88
Ash	17.78	17.63	17.94	
	100.00	100.00	100.00	100.00
Ultimate analysis:				
Hydrogen	3.95	4.01	3.89	4.74
Carbon	72.30	71.69	72.94	88.88
Nitrogen	1.55	1.54	1.57	1.91
Oxygen	3.74	4.46	2.98	3.64
Sulphur	.68	.67	.68	.83
Ash	17.78	17.63	17.94	
	100.00	100.00	100.00	100.00
Calorific value determined:				
Calories	6,951	6,892	7,013	8,546
B. t. u	12,512	12,406	12,623	15,383
Calorific value calculated from ultimate analysis:				
Calories		6,996		
B. t. u		12,593		

Fusing temperature of ash (in reducing atmosphere of molybdenum furnace), 1,227° C.=2,241° F. October 2, 1913.

INCLOSURE A8.

Laboratory No. 17897. Can No. 58239.
Sample of Pocahontas lump coal.
Method of sampling: Over seven-eighths-inch screen.
Net weight, 978.5 grams.
Date of laboratory sampling, October 22, 1913. Date of analysis, November 3, 1913.
For Bureau of Mines section, United States Naval Experiment Station, Annapolis, Md.

[Air-dry loss, 1.1.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.53	1.64		
Volatile matter	19.98	19.76	20.09	21.55
Fixed carbon	72.76	71.95	73.15	78.45
Ash	6.73	6.65	6.76	
	100.00	100.00	100.00	100.00
Ultimate analysis:				
Hydrogen	4.45	4.52	4.41	4.73
Carbon	84.19	83.25	84.64	90.78
Nitrogen	1.12	1.11	1.13	1.21
Oxygen	2.91	3.88	2.46	2.64
Sulphur	.60	.59	.60	.64
Ash	6.73	6.65	6.76	
	100.00	100.00	100.00	100.00
Calorific value determined:				
Calories	8,104	8,013	8,147	8,738
B. t. u	14,587	14,423	14,665	15,728
Calorific value calculated from ultimate analysis:				
Calories		8,129		
B. t. u		14,632		

Fusing temperature of ash, in reducing atmosphere: 1,370° C.=2,498° F. November 6, 1913.

INCLOSURE A9.

Laboratory No. 17896. Can No. 58240.
Sample of Pocahontas coal.
Method of sampling: Through seven-eighth-inch and on one-half-inch screen.
Net weight, 1,047.6 grams.
Date of laboratory sampling, October 21, 1913. Date of analysis, October 28, 1913.
For Bureau of Mines section, Naval Engineering Experiment Station, Annapolis, Md.

[Air-dry loss, 0.7.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.67	1.38		
Volatile matter	20.72	20.57	20.86	22.37
Fixed carbon	71.92	71.41	72.41	77.63
Ash	6.69	6.64	6.73	
	100.00	100.00	100.00	100.00
Ultimate analysis:				
Hydrogen	4.51	4.56	4.47	4.79
Carbon	83.78	83.19	84.35	90.44
Nitrogen	1.17	1.16	1.18	1.27
Oxygen	3.21	3.81	2.62	2.80
Sulphur	.64	.64	.65	.70
Ash	6.69	6.64	6.73	
	100.00	100.00	100.00	100.00
Calorific value determined:				
Calories	8,082	8,025	8,137	8,724
B. t. u	14,548	14,445	14,647	15,703
Calorific value calculated from ultimate analysis:				
Calories		8,142		
B. t. u		14,656		

Fusing temperature of ash, in reducing atmosphere: 1,313° C.=2,395° F.
November 5, 1913.

INCLOSURE A10.

Laboratory No. 17898. Can No. 55454.
Test No. P5.
Sample of Pocahontas coal.
Special marks: Through one-half inch and on one-fourth inch.
Net weight, 1,155.5 grams.
Date of laboratory sampling, October 21, 1913. Date of analysis, October 29, 1913.
For Bureau of Mines section, Naval Engineering Experiment Station, Annapolis, Md.

[Air-dry loss, 0.7.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.88	1.56		
Volatile matter	20.95	20.81	21.14	22.37
Fixed carbon	72.70	72.20	73.34	77.63
Ash	5.47	5.43	5.52	
	100.00	100.00	100.00	100.00
Ultimate analysis:				
Hydrogen	4.55	4.60	4.50	4.76
Carbon	84.74	84.16	85.49	90.48
Nitrogen	1.20	1.19	1.21	1.28
Oxygen	3.41	3.99	2.64	2.80
Sulphur	.63	.63	.64	.68
Ash	5.47	5.43	5.52	
	100.00	100.00	100.00	100.00
Calorific value determined:				
Calories	8,189	8,132	8,260	8,742
B. t. u	14,740	14,638	14,868	15,735
Calorific value calculated from ultimate analysis:				
Calories		8,227		
B. t. u		14,809		

Fusing temperature of ash, in reducing atmosphere: 1,375° C.=2,507° F.
November 5, 1913.

INCLOSURE A11.

Laboratory No. 17899. Can No. 55455.
Test No. P6.
Sample of Pocahontas coal.
Special marks: Through 4 mesh and on 10 mesh.
Net weight, 1,083.4 grams.
Date of laboratory sampling, October 21, 1913. Date of analysis, October 29, 1913.
For Bureau of Mines section, Naval Engineering Experiment Station Annapolis, Md.

[Air-dry loss, 0.8.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.91	1.69	....	....
Volatile matter	21.52	21.35	21.72	22.72
Fixed carbon	73.19	72.61	73.86	77.28
Ash	4.38	4.35	4.42	....
	100.00	100.00	100.00	100.00
Ultimate analysis:				
Hydrogen	4.70	4.75	4.64	4.85
Carbon	85.42	84.75	86.21	90.19
Nitrogen	1.23	1.22	1.24	1.30
Oxygen	3.57	4.24	2.79	2.93
Sulphur	.70	.69	.70	.73
Ash	4.38	4.35	4.42	....
	100.00	100.00	100.00	100.00
Calorific value determined:				
Calories	8,292	8,226	8,367	8,754
B. t. u	14,926	14,807	15,061	15,757
Calorific value calculated from ultimate analysis:				
Calories	....	8,318	....	....
B. t. u	....	14,972	....	....

Fusing temperature of ash, in reducing atmosphere: 1,271° C.=2,320° F.
November 5, 1913.

INCLOSURE A12.

Laboratory No. 17900. Can No. 55444.
Sample of Pocahontas coal.
Method of sampling: Dust through 10 mesh.
Net weight, 1,031.8 grams.
Date of laboratory sampling, October 22, 1913. Date of analysis, October 29, 1913.
For Bureau of Mines section, Naval Engineering Experiment Station Annapolis Md.

Air-dry loss, 1.7.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.79	2.46	....	....
Volatile matter	21.49	21.13	21.66	22.81
Fixed carbon	72.72	71.49	73.30	77.19
Ash	5.00	4.92	5.04	....
	100.00	100.00	100.00	100.00
Ultimate analysis:				
Hydrogen	4.70	4.81	4.65	4.90
Carbon	84.67	83.25	85.35	89.88
Nitrogen	1.23	1.21	1.24	1.31
Oxygen	3.55	4.97	2.86	3.00
Sulphur	.85	.84	.86	.91
Ash	5.00	4.92	5.04	....
	100.00	100.00	100.00	100.00
Calorific value determined:				
Calories	8,219	8,081	8,285	8,725
B. t. u	14,794	14,546	14,913	15,705
Calorific value calculated from ultimate analysis:				
Calories	....	8,189	....	....
B. t. u	....	14,740	....	....

Fusing temperature of ash, in reducing atmosphere: 1,234° C.=2,253°F.
November 5, 1913.

INCLOSURE A13.

Laboratory No. 17739. Can No. 55386.
Sample of Pocahontas No. 3 coal.
From Pocahontas Consolidated Collieries Co. (Inc.). Mine, "Baby."
State, Maryland. Bed, Pocahontas No. 3.
Town, Annapolis (engineering experiment station).
Method of sampling: Screenings through seven-eighths inch mesh; quartered.
Date of sampling, September 18, 1913. Date of analysis, September 30, 1913.
Collector, Charles Enzian.

[Air-dry loss, 1.2.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.75	1.90		
Volatile matter	21.81	21.56	21.98	23.14
Fixed carbon	72.46	71.62	73.00	76.86
Ash	4.98	4.92	5.02	
	100.00	100.00	100.00	100.00
Ultimate analysis:				
Hydrogen	4.82	4.89	4.77	5.02
Carbon	85.17	84.18	85.81	90.35
Nitrogen	1.23	1.22	1.24	1.31
Oxygen	3.08	4.08	2.44	2.56
Sulphur	.72	.71	.72	.76
Ash	4.98	4.92	5.02	
	100.00	100.00	100.00	100.00
Calorific value determined:				
Calories	8,210	8,115	8,272	8,710
B. t. u	14,778	14,607	14,890	15,678
Calorific value calculated from ultimate analysis:				
Calories		8,327		
B. t. u		14,989		

Real specific gravity, 1.33.
Fusing temperature of ash (in reducing atmosphere in molybdenum furnace), 1,227° C.=2,241° F.
October 1, 1913.

INCLOSURE A14.

Laboratory No. 17740. Can No. 55458.
Sample of coal (Pocahontas No. 3).
From Pocahontas Consolidated Collieries Co. (Inc.). Mine, "Baby."
State, Maryland.
Town, United States Naval Academy Engineering Experiment Station, Annapolis, Md.
Method of sampling: Over seven-eighth-inch mesh; hand-picked; quartered.
Date of sampling, September 18, 1913. Date of laboratory sampling, September 25. Date of analysis, September 30.
Collector, Charles Enzian.

[Air-dry loss, 0.9.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.48	1.38		
Volatile matter	21.80	21.60	21.90	22.75
Fixed carbon	73.99	73.32	74.35	77.25
Ash	3.73	3.70	3.75	
	100.00	100.00	100.00	100.00
Ultimate analysis:				
Hydrogen	4.74	4.80	4.72	4.90
Carbon	86.30	85.52	86.72	90.10
Nitrogen	1.22	1.21	1.23	1.28
Oxygen	3.31	4.08	2.88	2.99
Sulphur	.70	.69	.70	.73
Ash	3.73	3.70	3.75	
	100.00	100.00	100.00	100.00
Calorific value determined:				
Calories	8,377	8,302	8,418	8,746
B. t. u	15,079	14,944	15,152	15,743
Calorific value calculated from ultimate analysis:				
Calories		8,404		
B. t. u		15.127		

Fusing temperature of ash (in reducing atmosphere in molybdenum furnace): 1,213° C.=2,215° F. Real sp. gr., 1.29.
October 1, 1913.

INCLOSURE B.

TABLE I.—*Analyses of screened Bering River and Pocahontas coal (dry coal basis).*

BERING RIVER, ALASKA, COAL.

[Test 362. L. L.]

Inclosure	A1	A2	A3	A4	A5	A6	A7
Bureau of Mines Laboratory No.	17736	17741	17742	17734	17737	17735	17738
	As received, not cleaned or screened.	Hand-picked over ⅞-inch mesh.	Through ⅞-inch and over ½-inch mesh.	Through ½-inch and over 4 mesh.	Through 4 and over 10 mesh.	Slack through 10 mesh.	Screenings through ⅞-inch mesh.
Proximate:							
Volatile matter	16.37	18.55	17.46	16.32	15.78	15.23	16.51
Fixed carbon	69.57	75.84	69.77	67.19	66.46	58.23	65.55
Ash	14.06	5.61	12.77	16.49	17.76	26.54	17.94
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Ultimate:							
Hydrogen	4.09	4.37	4.17	3.94	3.98	3.54	3.89
Carbon	76.82	84.93	77.97	74.53	73.03	64.48	72.94
Nitrogen	1.53	1.62	1.57	1.52	1.53	1.39	1.57
Oxygen	2.80	2.78	2.84	2.83	3.00	3.44	2.98
Sulphur	.70	.69	.68	.69	.70	.61	.68
Ash	14.06	5.61	12.77	16.49	17.76	26.54	17.94
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
B. t. u.	13,286	14,726	13,495	12,924	12,703	11,169	12,623
Real specific gravity	1.43	....	1.45	....	....	....	....
Fusing temperature of ash, °F.	2,320	2,305	2,241	2,291	2,278	2,428	2,241
B. t. u. ash and moisture free	15,460	15,601	15,471	15,476	15,446	15,205	15,383

POCAHONTAS COAL.

Inclosure	A8	A9	A10	A11	A12	A13
Bureau of Mines Laboratory No.	17897	17896	17898	17899	17900	17739
	Over ⅞-inch mesh.	Through ⅞-inch and over ½-inch mesh.	Through ⅞-inch and over 4 mesh.	Through 4 and over 10 mesh.	Dust through 10 mesh.	Screenings through ⅞-inch mesh.
Proximate:						
Volatile matter	20.09	20.86	21.14	21.72	21.66	21.98
Fixed carbon	73.15	72.41	73.34	73.86	73.30	73.00
Ash	6.76	6.73	5.52	4.42	5.04	5.02
	100.00	100.00	100.00	100.00	100.00	100.00
Ultimate:						
Hydrogen	4.41	4.47	4.50	4.64	4.65	4.77
Carbon	84.64	84.35	85.49	86.21	85.35	85.81
Nitrogen	1.13	1.18	1.21	1.24	1.24	1.24
Oxygen	2.46	2.62	2.64	2.79	2.86	2.44
Sulphur	.60	.65	.64	.70	.86	.72
Ash	6.76	6.73	5.52	4.42	5.04	5.02
	100.00	100.00	100.00	100.00	100.00	100.00
B. t. u.	14,665	14,647	14,868	15,061	14,913	14,890
Real specific gravity	1.29	....	....	....	....	1.33
Fusing temperature of ash, °F.	2,498	2,395	2,507	2,320	2,253	2,241
B. t. u. ash and moisture free	15,728	15,703	15,736	15,757	15,705	15,678

INCLOSURE C.

FLOAT AND SINK TESTS, BERING RIVER COAL.

OCTOBER 11, 1913.

DIRECTOR: I inclose herewith Mr. A. C. Fieldner's reports on the float and sink tests of the Bering River coal samples gathered by Mr. Enzian, at the naval experimental station, Annapolis. September 20, 1913. Mr. Fieldner's letter explains the nature of the tests. I will add these comments:

Owing to not having exactly the same size screens as used at Annapolis, he used 1-inch instead of seven-eighths inch, but there would be no essential difference in the results. It was understood that only coal over 10 mesh in size would be suitable for the purposes of the Navy.

It will be observed that Mr. Fieldner states that the oversize was crushed and passed through the screens. In this respect it makes the results somewhat more favorable than would be in practice, since the oversize was known to be of better grade than the undersize. However, the difference is not serious.

In column 3, pages 1 and 2, is given the percentage of each size of the original sample. In column 4 is given the percentages of each size which is lighter than 1.35 specific gravity. It will be observed that in the coarser sizes above 10 mesh, 82 to 90 per cent is lighter than 1.35 specific gravity, and between 10 mesh and 60 mesh, 68 per cent is lighter than 1.35. This indicates that the washing would be a comparatively simple matter. The impurities are evidently separable from the coal, and for the most part are much heavier than the coal, so that there would be little difficulty in making the separation with a good coal-washing system, at least for coal over 60 mesh in size. As only 4.2 per cent passed through 60 mesh, this might be thrown away without the loss being serious, since it would represent only a small fraction of the total.

Column 5 shows the percentages of the original sample of the pure coal which might be considered less than 1.35 specific gravity. The following sizes are shown: 40.39 per cent of 1 inch to one-half inch, 14.95 per cent one-half inch to one-fourth inch, 15.78 per cent from one-fourth inch to 10 mesh, and 10.24 per cent from 10 mesh to 60 mesh, making a total of 81.36 per cent of the original sample which would be coal containing ash less than 2.87 per cent; this result showing better than the hand-picked coarser samples. This is an unusually favorable showing for washing. Of course, it would not be possible to obtain such good results in practice, but it is probable that the coal can be washed so that it will contain less than 5 per cent, and possibly 4 per cent, of ash.

I therefore recommend that the naval authorities proceed to assemble a temporary plant to wash the Bering River coal, amounting to about 50 tons or more now on hand. In this they can be assisted by Mr. Charles Enzian, who has already obtained agreements to supply a jig washer at the cost of transportation, the washer to be so set up that the raw coal can be weighed and put into the hopper for regular feeding, and arrangements made by means of a countershaft so that the speed of the jig can be varied to suit the kind of coal being washed. There should be a box or some temporary bin for the collection and sampling of the refuse slate; also a tight box for the collection of the pure coal, and a launder and settling box for retention and sampling of the coal sludge. Suitable water connections must be made to supply water to the jig.

Respectfully, yours,

GEO. S. RICE.

INCLOSURE C.

FLOAT AND SINK TESTS ON 108 POUNDS BERING RIVER COAL.

OCTOBER 11, 1913.

MR. RICE: On receipt at the laboratory, the entire sample was screened over a 1 inch screen. The oversize was crushed, taking care to avoid making fines, until all passed through the 1-inch screen. It was then mixed and divided. Fifty-four pounds (laboratory No. 17796) was sized. Each size except the dust through 60 mesh was subjected to float and sink tests on solutions of different gravities, thus dividing it into 5 fractions. The results are given in the attached table. All ash percentages are computed to the dry basis. The sums in column 7 are the computed percentages of ash in the coal of each size before floating. The sum in column 8, 11.16 per cent, is computed percentage of ash in the unwashed coal before sizing, which should check with the ash by direct analysis of the "as received" sample. The coal as received analyzed 10.49 per cent ash. This agreement proves the accuracy of the analytical work and the computed results.

In the lower section of the table is computed the percentage separation produced by each particular gravity of solution, also the per cent ash in the float and sink of each gravity.

The second half of the sample (54 pounds) was all crushed to pass one-half inch, mixed and divided, 27 pounds (laboratory No. 17834) being floated at one-half inch size and the other 27 pounds (laboratory No. 17833) being further crushed to one-fourth inch size and floated in a similar manner. The results are given in the table in the two groups below the results of the sized sample.

Yours, very truly,

A. C. Fieldner.

Inclosure C.

Results of float-and-sink tests on 108-pound sample of Bering River coal, taken by Charles Enzian, at the Naval Experiment Station, Annapolis.

[October 3, 1913. Laboratory No. 17798.]

Ash in raw coal (dry basis), 10.49 per cent.	Grams of each size.	Amount of each size in per cent of original sample.	Amount of each fraction in per cent of each size.	Amount of each fraction in per cent of original sample.	Amount of ash (dry basis) in each fraction.		
					As per cent of fraction.	As per cent of each size.	As per cent of original sample.
1	2	3	4	5	6	7	8
54 pounds, sized, laboratory No. 17798:							
1 inch to ½ inch	8,566	44.6					
Less than 1.35 specific gravity			90.54	40.39	2.72	2.46	
1.35 to 1.45			2.43	1.08	13.72	.33	
1.45 to 1.55			1.82	.81	23.37	.43	
1.55 to 1.65			.00	.00	.00	.00	
More than 1.65			5.21	2.32	66.39	3.46	
Sum			100.00	44.60		6.68	2.98
½ inch to ¼ inch	3,273	17.0					
Less than 1.35 specific gravity			87.97	14.95	2.77	2.44	
1.35 to 1.45			2.56	.44	14.92	.38	
1.45 to 1.55			.71	.12	24.38	.17	
1.55 to 1.65			.65	.11	32.75	.21	
More than 1.65			8.11	1.38	74.61	6.05	
Sum			100.00	17.00		9.25	1.57
¼ inch to 10 mesh	3,693	19.2			(13.57)		
Less than 1.35 specific gravity			82.18	15.78	2.82	2.32	
1.35 to 1.45			2.60	.50	21.13	.55	
1.45 to 1.55			1.42	.27	27.61	.39	
1.55 to 1.65			.88	.17	37.97	.33	
More than 1.65			12.92	2.48	73.91	9.55	
Sum			100.00	19.20		13.14	2.52

FLOAT-AND-SINK TEST 2.

1	2	3	4	5	6	7	8
10 mesh to 60 mesh	2,875	15.0					
Less than 1.35 specific gravity			68.25	10.24	2.87	1.96	
1.35 to 1.45			3.86	.58	12.97	.50	
1.45 to 1.55			2.55	.38	24.98	.64	
1.55 to 1.65			1.60	.24	32.57	.52	
More than 1.65			23.74	3.56	70.07	16.63	
Sum			100.00	15.00		20.25	3.04
60 mesh and finer	806	4.2				25.01	1.05
Total	19,213	100.0					11.16
Laboratory No. 17834					10.39		
27 pounds crushed to pass ½ inch							
½ inch to 60 mesh		94.74					
Less than 1.35 specific gravity			86.48	81.93	2.84	2.33	

Results of float-and-sink tests on 108-pound sample of Bering River coal, taken by Charles Enzian, at the Naval Experiment Station, Annapolis—Continued.

FLOAT-AND-SINK TEST 2—Continued.

Ash in raw coal (dry basis), 10.49 per cent.	Grams of each size.	Amount of each size in per cent of original sample.	Amount of each fraction in per cent of each size.	Amount of each fraction in per cent of original sample.	Amount of ash (dry basis) in each fraction.		
					As per cent of fraction.	As per cent of each size.	As per cent of original sample.
1	2	3	4	5	6	7	8
1.35 to 1.45			2.89	2.74	13.92	0.38	
1.45 to 1.55			1.05	.99	22.63	.22	
1.55 to 1.65			.57	.54	36.74	.20	
More than 1.65			9.01	8.54	72.37	6.18	
Sum			100.00	94.74		9.31	9.31
60 mesh and finer		5.26				21.82	1.15
Total		100.00					10.46
Laboratory No. 17833					10.58		
27 pounds crushed to pass ¼ inch		93.01					
¼ inch to 60 mesh							
Less than 1.35 specific gravity			85.48	79.49	3.15	2.50	
1.35 to 1.45			3.40	3.17	7.31	.23	
1.45 to 1.55			1.13	1.06	28.23	.30	
1.55 to 1.65			.81	.75	26.87	.20	
More than 1.65			9.18	8.54	71.10	6.07	
Sum			100.00	93.01		9.30	9.30
60 mesh and finer		6.99				17.56	1.23
Total		100.00					10.53

FLOAT-AND-SINK-TEST 3.

Description.	Specific gravity of solution.	Respective amounts of float and sink.				Per cent ash (dry basis).		
		As per cent of each size.		As per cent of original sample.				
		Float.	Sink.	Float.	Sink.	Float.	Sink.	Raw coal.
1	2	3	4	5	6	7	8	9
54-pound sized:								
1 inch to ½ inch	1.35	90.54	9.46	40.39	4.21	2.72	44.60	6.68
Do	1.45	92.97	7.03	41.47	3.13	3.01	55.26	
Do	1.55	94.79	5.21	42.28	2.32	3.40	66.39	
Do	1.65	94.79	5.21	42.28	2.32	3.40	66.39	
½ inch to ¼ inch	1.35	87.97	12.03	14.95	2.05	2.77	56.61	9.25
Do	1.45	90.53	9.47	15.39	1.61	3.12	68.01	
Do	1.55	91.24	8.76	15.51	1.49	3.28	71.52	
Do	1.65	91.89	8.11	15.62	1.38	3.49	74.61	
¼ inch to 10 mesh	1.35	82.18	17.82	15.78	3.42	2.82	60.75	13.14
Do	1.45	84.78	15.22	16.28	2.92	3.38	67.54	
Do	1.55	86.20	13.80	16.55	2.65	3.78	71.60	
Do	1.65	87.08	12.92	16.72	2.48	4.13	73.91	
10 mesh to 60 mesh	1.35	68.25	31.75	10.24	4.76	2.87	57.62	20.25
Do	1.45	72.11	27.89	10.82	4.18	3.41	63.82	
Do	1.55	74.66	25.34	11.20	3.80	4.14	67.70	
Do	1.65	76.26	23.74	11.44	3.56	4.74	70.07	
27 pounds crushed to ½ inch—								
½ inch to 60 mesh	1.35	86.48	13.52	81.93	12.81	2.84	54.52	9.31
Do	1.45	89.37	10.63	84.67	10.07	3.20	65.57	
Do	1.55	90.42	9.58	85.66	9.08	3.42	70.25	
Do	1.65	90.99	9.01	86.20	8.54	3.63	72.37	
27 pounds crushed to ¼ inch—								
¼ inch to 60 mesh	1.35	85.48	14.52	79.49	13.52	3.15	50.33	9.30
Do	1.45	88.88	11.12	82.66	10.35	3.31	63.50	
Do	1.55	90.01	9.99	83.72	9.29	3.63	67.53	
Do	1.65	90.82	9.18	84.47	8.54	3.83	71.10	

INCLOSURE D.

Results of float-and-sink tests on Pocahontas coal used in Bering River coal tests at the Naval Engineering Experiment Station, Annapolis, Oct. 25, 1913.

[Each sample except the 10-mesh coal was subjected to successive float-and-sink tests on solutions of 1.35, 1.45, 1.55, and 1.65, without any sizing or crushing. The 10-mesh sample was screened over 60-mesh, to remove the fine dust, which does not subside readily. The results are given in the following table. All ash percentages are computed to a dry basis.]

Description.	Amount of each fraction in per cent of each size.	Amount of ash (dry basis) in each fraction.	
		As per cent of fraction.	As per cent of size.
1	2	3	4
Label No. 17930; ash in dry coal, 6.19 per cent; lumps over ⅞-inch screen:			
Less than 1.35 specific gravity	85.90	3.21	2.76
1.35 to 1.45	4.26	12.00	.51
1.45 to 1.55	5.74	20.02	1.15
1.55 to 1.65	2.08	30.58	.64
More than 1.65	2.02	55.75	1.13
Sum	100.00		6.19
Label No. 17936; ash in dry coal, 6.60 per cent; lumps over ⅞-inch screen:			
Less than 1.35 specific gravity	86.34	3.40	2.94
1.35 to 1.45	5.37	12.78	.69
1.45 to 1.55	4.26	21.38	.91
1.55 to 1.65	1.53	29.98	.46
More than 1.65	2.50	63.98	1.60
Sum	100.00		6.60
Label No. 17942; ash in dry coal, 5.39 per cent; through ½-inch and on ¼-inch screen:			
Less than 1.35 specific gravity	90.50	2.94	2.66
1.35 to 1.45	4.03	13.48	.54
1.45 to 1.55	2.35	21.55	.51
1.55 to 1.65	1.18	30.61	.36
More than 1.65	1.94	67.86	1.32
Sum	100.00		5.39
Label No. 17948; ash in dry coal, 4.23 per cent; through ¼-inch on 10-mesh screen:			
Less than 1.35 specific gravity	95.74	2.42	2.32
1.35 to 1.45	.98	11.21	.11
1.45 to 1.55	1.21	19.92	.24
1.55 to 1.65	.54	28.80	.16
More than 1.65	1.53	72.31	1.11
Sum	100.00		3.94
Label No. 17954; ash in dry coal. 4.47 per cent; through 10-mesh on 60-mesh:			
Less than 1.35 specific gravity	93.12	1.83	1.70
1.35 to 1.45	2.53	8.78	.22
1.45 to 1.55	1.28	15.29	.20
1.55 to 1.65	.60	20.73	.12
More than 1.65	2.47	71.61	1.77
Sum	100.00		4.01
Label No. 17960; dust through 60-mesh from 10-mesh screenings		6.54	
		Grams.	*Per cent.*
Screenings through 10-mesh	10 to 60 mesh	1,785.8=	79.90
	Through 60-mesh	449.3=	20.10
		2,235.1	100.00

In the following table is shown the percentage of separation produced by each particular gravity of solution, also the per cent ash in the float and sink of each gravity:

[A. C. Fieldner, chemist.]

Description.	Specific gravity of solution.	Percentage of—		Percentage of ash (dry basis).		
		Float.	Sink.	Float.	Sink.	Raw coal.
1	2	3	4	5	6	7
Laboratory No. 17930; lump on ¾-inch screen	1.35	86	14	3.21	24.27	6.19
	1.45	90	10	3.63	29.59	
	1.55	96	4	4.61	42.98	
	1.65	98	2	5.16	55.75	
Laboratory No. 17936; through ¾-inch over ½-inch screen	1.35	86	14	3.40	26.76	6.60
	1.45	92	8	3.95	35.81	
	1.55	96	4	4.72	51.07	
	1.65	98	2	5.12	63.98	
Laboratory No. 17942; through ½-inch on ¼-inch screen	1.35	90	10	2.94	28.71	5.39
	1.45	95	5	3.39	39.93	
	1.55	97	3	3.83	53.77	
	1.65	98	2	4.15	67.86	
Laboratory No. 17948; through ¼-inch on 10-mesh screen	1.35	96	4	2.42	37.86	4.23
	1.45	97	3	2.51	45.82	
	1.55	98	2	2.72	60.96	
	1.65	98	2	2.87	72.31	
Laboratory No. 17954; through 10-mesh on 60-mesh	1.35	93	7	1.83	33.59	4.47
	1.45	96	4	2.01	48.02	
	1.55	97	3	2.18	61.67	
	1.65	98	2	2.30	71.61	

December 23, 1913.

[By A. C. Fieldner, chemist.]

INCLOSURE L1.

Laboratory No. 18312. Can No. 58860.
Sample of Bering River coal.
Remarks: Can received with top off, contents in mail bag; screened through ¾-inch on ½-inch screen; float on 1.65 specific gravity; sent from United States Naval Engineering Experiment Station.
Net weight, 1,097.2 grams.
Date of sampling, December 12, 1913. Date of laboratory sampling, December 22, 1913. Date of analysis, December 29, 1913.
For Bureau of Mines section, Navy Department.
Collector, Capt. T. W. Kinkaid.

[Air-dry loss, 1.4.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.54	1.94		
Volatile matter	18.06	17.81	18.16	19.17
Fixed carbon	76.15	75.07	76.56	80.83
Ash	5.25	5.18	5.28	
	100.00	100.00	100.00	100.00
Ultimate analysis:				
Hydrogen	4.29	4.39	4.25	4.49
Carbon	85.04	83.84	85.50	90.26
Nitrogen	1.80	1.77	1.81	1.91
Oxygen	2.88	4.09	2.42	2.56
Sulphur	.74	.73	.74	.78
Ash	5.25	5.18	5.28	
	100.00	100.00	100.00	100.00
Calorific value determined:				
Calories	8,199	8,083	8,243	8,702
B. t. u	14,758	14,549	14,837	15,664
Calorific value calculated from ultimate analysis:				
Calories		8,128		
B. t. u		14,629		

Fusing temperature of ash (reducing atmosphere): 1,340° C.=2,444° F.
January 19, 1914.

INCLOSURE L2.

Laboratory No. 18313. Can No. 55430.
Sample of Bering River coal.
Remarks: Screened through ¾-inch on ½-inch screen; sink on 1.65 specific gravity; sent from United States Naval Engineering Experiment Station.
Net weight. 861.7 grams.
Date of sampling December 12, 1913. Date of laboratory sampling, December 22, 1913. Date of analysis, December 30, 1913.
For Bureau of Mines section, Navy Department.
Collector, Capt. T. W. Kinkaid.

[Air-dry loss, 0.3.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.97	1.24		
Volatile matter	11.13	11.10	11.24	46.83
Fixed carbon	12.65	12.61	12.76	53.17
Ash	75.25	75.05	76.00	
	100.00	100.00	100.00	100.00

January 13, 1914.

INCLOSURE L3.

Laboratory No., 18302. Can No., 58845.
Sample of Bering River raw coal.
Remarks: Screened through ¾-inch on ½-inch screen; sent from United States naval engineering experiment station.
Net weight, 1,213.8 grams.
Date of sampling, December 10, 1913. Date of laboratory sampling, December 20, 1913. Date of analysis, December 23, 1913.
For Bureau of Mines section, Navy Department.
Collector, Capt. T. W. Kinkaid.

Air-dry loss.	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.78	1.14		
Volatile matter	17.22	17.16	17.36	19.46
Fixed carbon	71.27	71.01	71.83	80.54
Ash	10.73	10.69	10.81	
	100.00	100.00	100.00	100.00
Ultimate analysis:				
Hydrogen	4.14	4.17	4.09	4.59
Carbon	80.00	79.71	80.63	90.40
Nitrogen	1.75	1.74	1.76	1.97
Oxygen	2.68	2.99	2.00	2.24
Sulphur	.70	.70	.71	.80
Ash	10.73	10.69	10.81	
	100.00	100.00	100.00	100.00
Calorific value determined:				
Calories	7,696	7,668	7,756	8,696
B. t. u	13,853	13,802	13,961	15,653
Calorific value calculated from ultimate analysis:				
Calories		7,766		
B. t. u		13,979		

Fusing temperature of ash (in reducing atmosphere), 1,291° C. = 2,356° F.
January 19, 1914.

INCLOSURE L4.

Laboratory No. 18303. Can No. 58846.
Sample of Bering River washed coal.
Remarks: Screened through ⅞-inch on ½-inch screen; sent from United States Naval Engineering Experiment Station.
Net weight, 1,163.7 grams.
Date of sampling December 11, 1913. Date of laboratory sampling, December 22, 1913. Date of analysis, December 27, 1913.
For Bureau of Mines section, Navy Department.
Collector, Capt. T. W. Kinkaid.

[Air-dry loss, 1.7.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.44	2.17	....	....
Volatile matter	18.56	18.24	18.64	19.78
Fixed carbon	75.25	73.94	75.58	80.22
Ash	5.75	5.65	5.78	....
	100.00	100.00	100.00	100.00
Ultimate analysis:				
Hydrogen	4.58	4.69	4.55	4.83
Carbon	84.85	83.37	85.22	90.44
Nitrogen	1.79	1.76	1.80	1.91
Oxygen	2.28	3.79	1.89	2.01
Sulphur	.75	.74	.76	.81
Ash	5.75	5.65	5.78	....
	100.00	100.00	100.00	100.00
Calorific value determined:				
Calories	8,162	8,020	8,198	8,701
B. t. u	14,692	14,436	14,756	15,662
Calorific value calculated from ultimate analysis:				
Calories	....	8,207	....	....
B. t. u	....	14,773	....	....

Fusing temperature of ash (reducing atmosphere) 1,328° C. = 2,422° F.
January 19, 1914.

INCLOSURE L5.

Laboratory No. 18304. Can No. 58851.
Sample of Bering River refuse coal.
Remarks: Screened through ⅞ inch on ½ inch screen; sent from United States Naval Engineering Experiment Station.
Net weight, 1431 grams.
Date of sampling, December 11, 1913. Date of laboratory sampling, December 23, 1913. Date of analysis, January 3, 1,914.
For Bureau of Mines section, Navy Department.
Collector, Capt. T. W. Kinkaid.

[Air-dry loss 2.1.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.88	2.91	....	....
Volatile matter	14.62	14.32	14.75	25.27
Fixed carbon	43.22	42.34	43.61	74.73
Ash	41.28	40.43	41.64	....
	100.00	100.00	100.00	100.00

January 13, 1914.

INCLOSURE L6.

Laboratory No. 18310. Can No. 55429.
Sample of Bering River coal.
Remarks: Screened through one-half inch on 4-mesh screen: 1.65 specific gravity float; sent from United States Naval Engineering Experiment Station.
Net weight, 1,033.5 grams.
Date of sampling, December 12, 1913. Date of laboratory sampling, December 23, 1913. Date of analysis, December 29, 1913.
For Bureau of Mines section, Navy Department.
Collector, Capt. T. W. Kinkaid.

[Air-dry loss, 3.6.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.85	4.39	....	....
Volatile matter	16.85	16.25	17.00	17.78
Fixed carbon	77.95	75.17	78.62	82.22
Ash	4.35	4.19	4.38	....
	100.00	100.00	100.00	100.00
Ultimate analysis:				
Hydrogen	4.39	4.63	4.33	4.53
Carbon	86.07	83.00	86.81	90.79
Nitrogen	1.90	1.83	1.91	2.00
Oxygen	2.58	5.67	1.86	1.94
Sulphur	.71	.68	.71	.74
Ash	4.35	4.19	4.38	....
	100.00	100.00	100.00	100.00
Calorific value determined:				
Calories	8,304	8,008	8,376	8,760
B. t. u	14,947	14,414	15,077	15,768
Calorific value calculated from ultimate analysis:				
Calories	....	8,073	....	....
B. t. u	....	14,531	....	....

Fusing temperature of ash (in reducing atmosphere): 1,365° C.=2,489° F.
January 19, 1914.

INCLOSURE L7.

Laboratory No. 18311. Can No. 55431.
Sample of Bering River coal.
Remarks: Screened through one-half inch on 4-mesh screen; sink on 1.65 specific gravity; sent from United States Naval Engineer Experiment Station.
Net weight, 1,100.2 grams.
Date of sampling, December 12, 1913. Date of laboratory sampling, December 23, 1913. Date of analysis, December 31, 1913.
For Bureau of Mines section, Navy Department.
Collector, Capt. T. W. Kinkaid.

[Air-dry loss, 1.8.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	1.15	2.97	....	....
Volatile matter	10.95	10.75	11.08	43.48
Fixed carbon	14.23	13.97	14.40	56.52
Ash	73.67	72.31	74.52	....
	100.00	100.00	100.00	100.00

January 13, 1914.

INCLOSURE L8.

Laboratory No. 18298. Can No. 55423.
Sample of Bering River raw coal.
Remarks: Screened through ½ inch on 4-mesh; sent from United States Naval Engineering Experiment Station.
Net weight, 1,289.5 grams.
Date of sampling, December 10, 1913. Date of laboratory sampling, December 20, 1913. Date of analysis, December 22, 1913.
For Bureau of Mines section, Navy Department.
Collector, Capt. T. W. Kinkaid.

[Air-dry loss, 0.4.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.60	1.01		
Volatile matter	17.15	17.08	17.25	19.80
Fixed carbon	69.45	69.16	69.87	80.20
Ash	12.80	12.75	12.88	
	100.00	100.00	100.00	100.00
Ultimate analysis:				
Hydrogen	4.02	4.05	3.98	4.57
Carbon	77.54	77.22	78.01	89.54
Nitrogen	1.73	1.72	1.74	2.00
Oxygen	3.23	3.58	2.70	3.10
Sulphur	.68	.68	.69	.79
Ash	12.80	12.75	12.88	
	100.00	100.00	100.00	100.00
Calorific value determined:				
Calories	7,469	7,438	7,514	8,625
B. t. u	13,444	13,388	13,525	15,525
Calorific value calculated from ultimate analysis:				
Calories		7,495		
B. t. u		13,491		

Fusing temperature of ash (in reducing atmosphere): 1,291° C=2,356° F.
January 19, 1914.

INCLOSURE L9.

Laboratory No. 18297. Can No. 58237.
Sample of Bering River washed coal.
Remarks: Screened through ½-inch on 4 mesh; sent from United States Naval Engineering Experiment Station.
Net weight, 1216.8 grams.
Date of sampling, December 10, 1913. Date of laboratory sampling, December 22, 1913. Date of analysis, December 26, 1913.
For Bureau of Mines section, Navy Department.
Collector, Capt. T. W. Kinkaid.

[Air-dry loss, 3.0.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.53	3.54		
Volatile matter	17.62	17.09	17.72	19.01
Fixed carbon	75.10	72.82	75.49	80.99
Ash	6.75	6.55	6.79	
	100.00	100.00	100.00	100.00
Ultimate analysis:				
Hydrogen	4.17	4.38	4.14	4.44
Carbon	83.54	81.01	83.98	90.09
Nitrogen	1.75	1.70	1.76	1.89
Oxygen	3.11	5.70	2.65	2.85
Sulphur	.68	.66	.68	.73
Ash	6.75	6.55	6.79	
	100.00	100.00	100.00	100.00
Calorific value determined:				
Calories	8,045	7,801	8,087	8,676
B. t. u	14,481	14,042	14,557	15,617
Calorific value calculated from ultimate analysis:				
Calories		7,825		
B. t. u		14,085		

Fusing temperature of ash (in reducing atmosphere): 1,295° C.=2,363° F.
January 19, 1914.

INCLOSURE L10.

Laboratory No. 18301. Can No. 58552.
Sample of Bering River refuse coal.
Remarks: Screened through one-half inch on 4-mesh; sent from United States Naval Engineering Experiment Station.
Net weight, 1,292.9 grams.
Date of sampling, December 10, 1913. Date of laboratory sampling, December 22, 1913. Date of analysis, December 30, 1913.
For Bureau of Mines section, Navy Department.
Collector, Capt. T. W. Kinkaid.

[Air-dry loss, 3.2.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.64	3.81	....	....
Volatile matter	15.01	14.53	15.11	21.12
Fixed carbon	56.07	54.28	56.43	78.88
Ash	28.28	27.38	28.46	....
	100.00	100.00	100.00	100.00

January 13, 1914.

INCLOSURE L11.

Laboratory No. 18308. Can No. 55450.
Sample of Bering River coal.
Remarks: Screened through 4-mesh on 10-mesh screen; 1.65 specific gravity float; sent from United States Naval Engineering Experiment Station.
Net weight, 1,118.2 grams.
Date of sampling, December 12, 1913. Date of laboratory sampling, December 23, 1913. Date of analysis, December 29, 1913.
For Bureau of Mines section, Navy Department.
Collector, Capt. T. W. Kinkaid.

[Air-dry loss, 5.8.]

	Air dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.83	6.53	....	....
Volatile matter	19.07	17.97	19.23	20.22
Fixed carbon	75.25	70.93	75.88	79.78
Ash	4.85	4.57	4.89	....
	100.00	100.00	100.00	100.00
Ultimate analysis:				
Hydrogen	4.30	4.69	4.24	4.46
Carbon	85.11	80.22	85.83	90.24
Nitrogen	1.81	1.71	1.83	1.92
Oxygen	3.26	8.18	2.54	2.68
Sulphur	.67	.63	.67	.70
Ash	4.85	4.57	4.89	....
	100.00	100.00	100.00	100.00
Calorific value determined:				
Calories	8,206	7,734	8,275	8,700
B. t. u	14,771	13,921	14,895	15,660
Calorific value calculated from ultimate analysis:				
Calories	....	7,761	....	....
B. t. u	....	13,970	....	....

Fusing temperature of ash (reducing atmosphere): 1,340° C.=2,444° F.
January 19, 1914.

INCLOSURE L12.

Laboratory No. 18309. Can No. 55451.
Sample of Bering River coal.
Remarks: Screened through 4-mesh on 10-mesh screen; 1.65 specific gravity sink; sent from United States Naval Engineer Experiment Station.
Net weight, 1,593.2 grams.
Date of sampling December 12, 1913. Date of laboratory sampling, December 24, 1913. Date of analysis, December 31, 1913.
For Bureau of Mines section, Navy Department.
Collector, Capt. T. W. Kinkaid.

[Air-dry loss 8.4.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	1.23	9.57	....	....
Volatile matter	11.00	10.07	11.14	39.87
Fixed carbon	16.59	15.19	16.80	60.13
Ash	71.18	65.17	72.06	....
	100.00	100.00	100.00	100.00

January 13, 1914.

INCLOSURE L13.

Laboratory No. 18296. Can No. 55388.
Sample of Bering River raw coal.
Remarks: Can received with cover off, contents in mail bag; screened through 4-mesh on 10-mesh; sent from United States Naval Engineering Experiment Station.
Net weight, 1,163.9 grams.
Date of sampling, December 10, 1913. Date of laboratory sampling, December 20, 1913. Date of analysis, December 22, 1913.
For Bureau of Mines section, Navy Department.
Collector, Capt. T. W. Kinkaid.

[Air-dry loss, 0.3.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.73	1.07	....	....
Volatile matter	16.52	16.46	16.64	20.40
Fixed carbon	64.46	64.24	64.93	79.60
Ash	18.29	18.23	18.43	....
	100.00	100.00	100.00	100.00
Ultimate analysis:				
Hydrogen	3.69	3.72	3.64	4.46
Carbon	72.06	71.81	72.59	88.99
Nitrogen	1.44	1.44	1.46	1.79
Oxygen	3.87	4.15	3.22	3.95
Sulphur	.65	.65	.66	.81
Ash	18.29	18.23	18.43	....
	100.00	100.00	100.00	100.00
Calorific value determined:				
Calories	6,898	6,875	6,949	8,519
B. t. u	12,416	12,375	12,508	15,334
Calorific value calculated from ultimate analysis:				
Calories	....	6,920	....	....
B. t. u	....	12,456	....	....

Fusing temperature of ash (in reducing atmosphere), 1,300° C. = 2,372° F.
January 19, 1914.

INCLOSURE L14.

Laboratory No. 18300. Can No. 55397.
Sample of Bering River washed coal.
Remarks: Screened through 4-mesh on 10-mesh; sent from United States Naval Engineering Experiment Station.
Net weight, 1,153.9 grams.
Date of sampling, December 10, 1913. Date of laboratory sampling, December 20, 1913. Date of analysis, December 26, 1913.
For Bureau of Mines section, Navy Department.
Collector, Capt. T. W. Kinkaid.

[Air-dry loss, 8.1.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.64	8.65		
Volatile matter	18.21	16.74	18.33	20.75
Fixed carbon	69.57	63.96	70.01	79.25
Ash	11.58	10.65	11.66	
	100.00	100.00	100.00	100.00
Ultimate analysis:				
Hydrogen	3.76	4.36	3.72	4.21
Carbon	78.66	72.32	79.17	89.62
Nitrogen	1.75	1.61	1.76	1.99
Oxygen	3.58	10.44	3.01	3.41
Sulpher	.67	.62	.68	.77
Ash	11.58	10.65	11.66	
	100.00	100.00	100.00	100.00
Calorific value determined:				
Calories	7,564	6,954	7,613	8,618
B. t. u	13,615	12,517	13,703	15,512
Calorific value calculated from ultimate analysis:				
Calories		6,908		
B. t. u		12,434		

Fusing temperature of ash (in reducing atmosphere): 1,334° C.=2,433° F.
January 19, 1914.

INCLOSURE L15.

Laboratory No. 18299. Can No. 55408.
Sample of Bering River refuse coal.
Remarks: Screened through 4-mesh on 10-mesh; sent from United States Naval Engineering Experiment Station.
Net weight, 1,343.6 grams.
Date of sampling, December 10, 1913. Date of laboratory sampling, December 22, 1913. Date of analysis, December 30, 1913.
For Bureau of Mines section, Navy Department.
Collector, Capt. T. W. Kinkaid.

[Air-dry loss, 5.8.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.79	6.58		
Volatile matter	13.91	13.10	14.02	23.23
Fixed carbon	45.97	43.29	46.34	76.77
Ash	39.33	37.03	39.64	
	100.00	100.00	100.00	100.00

January 13, 1914.

INCLOSURE L16.

Laboratory No. 18306. Can No. 58863.
Sample of Bering River washed coal.
Remarks: Mixture from refuse pile; sent from United States Naval Engineering Experiment Station.
Net weight, 1,160.9 grams.
Date of sampling, December 11, 1913. Date of laboratory sampling, December 23, 1913. Date of analysis, December 29, 1913.
For Bureau of Mines section, Navy Department.
Collector, Capt. T. W. Kinkaid.

[Air-dry loss, 3.1.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.80	3.86		
Volatile matter	17.40	16.86	17.54	19.06
Fixed carbon	73.90	71.62	74.49	80.94
Ash	7.90	7.66	7.97	
	100.00	100.00	100.00	100.00
Ultimate analysis:				
Hydrogen	4.10	4.31	4.04	4.39
Carbon	82.03	79.50	82.69	89.85
Nitrogen	1.72	1.67	1.74	1.89
Oxygen	3.55	6.18	2.85	3.10
Sulphur	.70	.68	.71	.77
Ash	7.90	7.66	7.97	
	100.00	100.00	100.00	100.00
Calorific value determined:				
Calories	7,933	7,689	7,997	8,690
B. t. u	14,279	13,840	14,395	15,642
Calorific value calculated from ultimate analysis:				
Calories		7,659		
B. t. u		13,786		

Fusing temperature of ash (reducing atmosphere): 1,322° C. =2,412° F.
January 19, 1914.

INCLOSURE L17.

Laboratory No. 18307. Can No. 58873.
Sample of Bering River refuse coal.
Remarks: Mixture from refuse pile; sent from United States Naval Engineering Experiment Station.
Net weight, 1,574.8 grams.
Date of sampling, December 11, 1913. Date of laboratory sampling, December 23, 1913. Date of analysis, December 30, 1913.
For Bureau of Mines section, Navy Department.
Collector, Capt. T. W. Kinkaid.

[Air-dry loss, 4.0.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	1.10	5.09		
Volatile matter	12.53	12.03	12.67	28.70
Fixed carbon	31.12	29.86	31.47	71.30
Ash	55.25	53.02	55.86	
	100.00	100.00	100.00	100.00

January 13, 1914.

INCLOSURE L18.

Laboratory No. 18305. Can No. 55428.
Sample of Bering River hutch refuse coal.
Remarks: Received in can with cover off, but coal remained; sent from United States Naval Engineering Experiment Station.
Net weight, 1,736.5 grams.
Date of sampling, December 11, 1913. Date of laboratory sampling, December 27, 1913. Date of analysis, December 31, 1913.
For Bureau of Mines section, Navy Department.
Collector Capt. T. W. Kinkaid.

[Air-dry loss, 20.8.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.85	21.48	....	....
Volatile matter	14.75	11.68	14.88	21.44
Fixed carbon	54.07	42.82	54.53	78.56
Ash	30.33	24.02	30.59	....
	100.00	100.00	100.00	100.00

January 13, 1914.

INCLOSURE M.

TABLE II.—*Bering River, Alaska, coal, coal analyses, dry basis, samples from washing operations.*

[Test 362. L. L.]

Inclosure No	L1	L2	L3	L4	L5
Bureau of Mines Laboratory No	18312	18313	18302	18303	18304
Screened size	⅞–½ inch.	⅞–½ inch.	⅞–½ inch.	⅞–½ inch.	⅞–½ inch.
Character of sample	Float on 1.65 sp. gr.	Sink on 1.65 sp. gr.	Raw coal.	Washed coal.	Refuse.
Proximate analysis:					
Volatile matter	18.16	11.24	17.36	18.64	14.75
Fixed carbon	76.56	12.76	71.83	75.58	43.61
Ash	5.28	76.00	10.81	5.78	41.64
	100.00	100.00	100.00	100.00	100.00
Ultimate analysis:					
Hydrogen	4.25	....	4.09	4.55	....
Carbon	85.50	....	80.63	85.22	....
Nitrogen	1.81	....	1.76	1.80	....
Oxygen	2.42	....	2.00	1.83	....
Sulphur	.74	....	.71	.76	....
Ash	5.28	....	10.81	5.78	....
	100.00	....	100.00	100.00	....
B. t. u.	14,837	....	13,961	14,756	....
Fusing temperature, ° F.	2,444	....	2,356	2,422	....
B. t. u. ash and moisture free	15,664	....	15,653	15,662	....

TABLE II.—*Bering River, Alaska, coal, coal analyses, dry basis, samples from washing operations*—Continued.

Inclosure No.	L6	L7	L8	L9	L10
Bureau of Mines Laboratory No.	18310	18311	18298	18297	18301
Screened size	½ inch, 4 mesh.	½ inch, 4 mesh.	½ inch, 4 mesh.	½ inch, 4 mesh.	½ inch. 4 mesh.
Character of sample	Float on 1.65 sp. gr.	Sink on 1.65 sp. gr.	Raw coal.	Washed coal.	Refuse.
Proximate analysis:					
Volatile matter	17.00	11.08	17.25	17.72	15.11
Fixed carbon	78.62	14.40	69.87	75.49	56.43
Ash	4.38	74.52	12.88	6.79	28.46
	100.00	100.00	100.00	100.00	100.00
Ultimate analysis:					
Hydrogen	4.33		3.98	4.14	
Carbon	86.81		78.01	83.98	
Nitrogen	1.91		1.74	1.76	
Oxygen	1.86		2.70	2.65	
Sulphur	.71		.69	.68	
Ash	4.38		12.88	6.79	
	100.00		100.00	100.00	
B. t. u.	15,077		13,525	14,557	
Fusing temperature, ° F.	2,489		2,356	2,363	
B. t. u. ash and moisture free	15,768		15,525	15,617	

Inclosure No.	L11	L12	L13	L14	L15
Bureau of mines Laboratory No.	18308	18309	18296	18300	18299
Screened rize	4-10 mesh.	4-10 mesh.	4-10 mesh.	4-10 mesh.	4-10 mesh.
Character of sample	Float on 1.65 sp. gr.	Sink on 1.65 sp. gr.	Raw coal.	Washed coal.	Refuse.
Proximate analysis:					
Volatile matter	19.23	11.14	16.64	18.33	14.02
Fixed carbon	75.88	16.80	64.93	70.01	46.34
Ash	4.89	72.06	18.43	11.66	39.64
	100.00	100.00	100.00	100.00	100.00
Ultimate analysis:					
Hydrogen	4.24		3.64	3.72	
Carbon	85.83		72.59	79.17	
Nitrogen	1.83		1.46	1.76	
Oxygen	2.54		3.22	3.01	
Sulphur	.67		.66	.68	
Ash	4.89		18.43	11.66	
	100.00		100.00	100.00	
B. t. u.	14,895		12,508	13,703	
Fusing temperature, °F.	2,444		2,372	2,433	
B. t. u. ash and moisture free	15,660		15,334	15,512	

TABLE II.—*Bering River, Alaska, coal, coal analyses, dry basis, samples from washing operations*—Continued.

Inclosure No	L16	L17	L13
Bureau of Mines Laboratory No	18306	18307	18305
Screened size	Mixed.	Mixed.	Hutch refuse.
Character of sample	Rewashed refuse pile.	Refuse of L16.	Hutch refuse.
Proximate analysis:			
Volatile matter	17.54	12.67	14.88
Fixed carbon	74.49	31.47	54.53
Ash	7.97	55.86	30.59
	100.00	100.00	100.00
Ultimate analysis:			
Hydrogen	4.04	....	....
Carbon	82.69	....	....
Nitrogen	1.74	....	....
Oxygen	2.85	....	....
Sulphur	.71	....	....
Ash	7.97	....	....
	100.00	....	....
B. t. u	14,395	....	....
Fusing temperature, °F	2,412	....	....
B. t. u. ash and moisture free	15,642	....	....

INCLOSURE N.

TABLE III.—*Data and results of washery operations.*

	Size of coal.			
	⅞–½ inch.	½ inch–4 mesh.	4–10 mesh.	Refuse.
Speed of plunger, revolutions per minute	103	106–128	107	102
Length of plunger stroke, inches	1	2	2	2
Time of washing, hours	3.55	3.57	4.25	....
Weight of raw coal fed, pounds	11,559	14,170	15,646	3,623
Coal washed per hour, pounds	3,257	3,969	3,681	....
Weight of washed coal, pounds	10,029	10,557	13,589	1,830
Weight of refuse removed, pounds	1,650	3,762	3,672	1,852
Moisture in raw coal, per cent	1.14	1.01	1.07	3.36
Moisture in washed coal, per cent	2.17	3.54	8.65	3.86
Moisture in refuse, per cent	2.91	3.81	6.58	5.09
Total weight of dry coal and refuse:				
Weight of raw coal, pounds	11,427	14,027	15,479	3,501
Weight of washed coal, pounds	9,811	10,183	12,413	1,759
Weight of refuse, pounds	1,602	3,619	3,430	1,758
Unaccounted for as refuse	14	225	—364	—16
Float and sink tests on 1.65 specific gravity:				
Raw coal, float, per cent	90.8	87.8	79.8	46.5
Raw coal, sink, per cent	9.2	12.2	20.2	53.5
Washed coal, float, per cent	95.9	94.7	91.3	95.8
Washed coal, sink, per cent	4.1	5.3	8.7	4.2
Refuse, float, per cent	41.8	51.2	47.7	22.0
Refuse, sink, per cent	58.2	48.8	52.3	78.0
Analyses of ash in dry coal:				
Float on 1.65 specific gravity, per cent	5.28	4.38	4.89	....
Sink on 1.65 specific gravity, per cent	76.00	74.52	72.06	....
Raw coal, per cent	10.81	12.88	18.43	35.05
Washed coal, per cent	5.78	6.79	11.66	7.97
Refuse, per cent	41.64	28.46	39.64	55.86
Deduced results:				
Ash reduction, per cent	46.50	47.28	36.72	77.23
Washed coal by weight, per cent	85.86	72.59	80.20	50.24
Refuse by weight, per cent	14.14	27.41	19.80	49.76
Washed coal by analysis, per cent	85.97	71.90	75.80	43.45
Refuse by analysis, per cent	14.03	28.10	24.20	56.55
Ash removed, per cent	54.02	62.05	52.04	90.13
Dry ash in raw coal, calculated per cent	11.79	12.94	18.45	....

INCLOSURE O.

TABLE IV.—*Table of data and results of evaporative test, Pocahontas and Bering River (Alaska) coals.*

	Pocahontas.	Bering River.
GENERAL.		
Run No.	1	2
Date	(1)	(2)
Duration, hours	24	24
AVERAGE PRESSURES.		
Barometer, inches of mercury	29.99	29.82
Barometer, pounds per square inch	14.74	14.65
Steam, pounds per square inch, gauge	300.2	298.0
Steam, pounds per square inch, absolute	314.9	312.7
Draft, ash pit, inches of water	0.000	0.000
Draft, furnace, inches of water	.325	.423
Draft, base of stack, inches of water	.750	.748
AVERAGE TEMPERATURES, DEGREES FAHRENHEIT.		
External air	45.8	45.4
Fire room	62.5	62.5
Steam by thermometer	421.0	421.4
Steam from pressure	421.9	420.9
Feed water entering boiler	183.9	188.1
Gases in furnace	1,835	1,566
Gases at base of stack	744	674
Gases at base of stack by thermometer	764	698
WEATHER AND HUMIDITY.		
State of weather	(3)	(4)
Wind direction	(5)	(6)
Wind velocity, miles per hour	2.3	6.7
Wet-bulb thermometer, degrees Fahrenheit	52.0	52.6
Dew point by hygrometer degrees Fahrenheit	41.2	39.5
Relative humidity from wet bulb	47.1	50.0
Relative humidity from hygrometer	47.6	44.7
Average relative humidity	47.4	47.4
Moisture per cubic foot of air, pounds	0.00042	0.00043
Dry air per cubic foot of air, pounds	0.07553	0.07507
TOTAL FUEL.		
Trade name	(7)	(8)
Size of coal	(9)	(10)
Coal as fired, pounds	35,740	27,160
Moisture by analysis, per cent	2.37	1.58
Dry coal consumed, pounds	34,893	26,731
Dry ash from ash pit, pounds	1,780	909
Dry clinker from grate, pounds	739	1,267
Dry clinker from bridge wall, pounds	187	16
Dry soot from tubes and baffles, pounds	35	36
Total dry ash, clinker and soot, pounds	2,741	2,228
Combustible consumed, pounds	32,152	24,503
Ashes and clinker in dry coal, per cent	7.76	8.20
PROXIMATE ANALYSIS OF COAL AS FIRED.		
Moisture, per cent	2.37	1.58
Volatile matter, per cent	21.01	17.25
Fixed carbon, per cent	71.10	75.83
Ash, per cent	5.52	5.34
Sulphur (separately determined), per cent	.78	.72
ULTIMATE ANALYSIS OF DRY COAL.		
Carbon, per cent	84.95	85.90
Hydrogen, per cent	4.48	4.30
Oxygen, per cent	2.94	1.85
Nitrogen, per cent	1.18	1.80
Sulphur, per cent	.79	.73
Ash, per cent	5.66	5.42
Moisture in coal as received, associated with dry coal, per cent	2.43	1.61

[1] Dec. 16, 17 1913.
[2] Dec. 17, 18, 1913.
[3] Clear.
[4] Partly cloudy to clear.
[5] S. to SSW.
[6] NNW. to WNW.
[7] Pocahontas No. 1.
[8] Bering River big vein.
[9] Run of mine
[10] Lump over 4-mesh.

TABLE IV.—*Table of data and results of evaporative test, Pocahontas and Bering River (Alaska) coals*—Continued.

	Pocahontas	Bering River.
ULTIMATE ANALYSIS OF COAL, ASH, AND MOISTURE FREE.		
Carbon, per cent	90.04	90.82
Hydrogen, per cent	4.75	4.55
Oxygen, per cent	3.12	1.95
Nitrogen, per cent	1.25	1.91
Sulphur per cent	.84	.77
ANALYSIS OF ASHES FROM ASH PIT.		
Carbon, per cent	59.90	46.06
Ash, per cent	40.10	53.94
ANALYSIS OF CLINKER FROM GRATE.		
Carbon, per cent	12.51	19.37
Ash, per cent	87.49	80.63
ANALYSIS OF CLINKER FROM BRIDGE WALL.		
Carbon, per cent	8.90	.88
Ash, per cent	91.10	99.12
ANALYSIS OF SOOT FROM TUBES AND BAFFLE WALLS.		
Carbon, per cent	46.47	48.89
Ash, per cent	53.53	51.11
CALORIFIC VALUES.		
Dry coal by calorimeter, B. t. u. per pound	14,786	14,844
Coal, ash, and moisture free, by calorimeter	15,673	15,794
Dry coal from analysis, B. t. u. per pound	14,940	15,047
Coal, ash, and moisture free, from analysis	15,836	15,910
FUEL PER HOUR.		
Dry coal consumed, pounds	1,454	1,114
Combustible consumed, pounds	1,340	1,021
Dry coal per square foot of grate surface, pounds	24.95	19.11
Combustible per square foot of grate surface, pounds	22.99	17.51
STEAM QUALITY.		
Throttling calorimeter temperature, degrees Fahrenheit	323.1	322.5
Throttling calorimeter pressure, pounds gauge	11.50	11.32
Quality, per cent dry	99.38	99.41
Moisture in steam, per cent	0.62	0.59
Heat in dry saturated steam above feed temperature, B. t. u. per pound	1,052.9	1,048.4
Heat in wet steam above feed temperature, B. t. u. per pound	1,047.9	1,043.6
Factor of correction for steam quality	.9953	.9954
Factor of evaporation	1.0850	1.0804
TOTAL WATER.		
Water fed to boiler, pounds	324,355	242,908
Water evaporated, corrected for moisture, pounds	322,831	241,791
Equivalent evaporation from and at 212° F., pounds	350,272	261,231
WATER PER HOUR.		
Water evaporated corrected for moisture, pounds	13,451	10,075
Equivalent evaporation, from and at 212° F., pounds	14,595	10,885
Equivalent evaporation, from and at 212° F., per square foot of water-heating surface, pounds	6.75	5.04
CAPACITY.		
Boiler horsepower developed	422.9	315.5
Rated boiler horsepower	216.1	216.1
Proportion of rated capacity attained, per cent	195.7	146.1
ECONOMIC RESULTS.		
Water fed per pound of coal fired, pounds	9.08	8.94
Equivalent dry saturated steam evaporated per pound dry coal pounds	9.25	9.05
Equivalent evaporated from and at 212° F. per pound of coal fired, pounds	9.80	9.62
Equivalent evaporated from and at 212° F. per pound of dry coal, pounds	10.04	9.77
Equivalent evaporated from and at 212° F. per pound of combustible, pounds	10.89	10.66

TABLE IV.—*Table of data and results of evaporative test, Pocahontas and Bering River (Alaska) coals*—Continued.

	Pocahontas.	Bering River.
EFFICIENCY.		
Boiler, furnace, and grate, per cent	65.89	63.87
Boiler and furnace, per cent	67.43	65.49
Smoke by Ringelmann's smoke chart, per cent	59.4	27.4
ANALYSIS OF DRY GASES, BY VOLUME.		
Carbon dioxide in first pass, per cent	12.80	10.08
Oxygen in first pass, per cent	5.76	9.31
Carbon monoxide in first pass, per cent	0.47	0.31
Hydrogen and hydrocarbons in first pass, per cent	0.00	0.00
Nitrogen in first pass (by difference), per cent	80.97	80.30
Carbon dioxide at base of stack, per cent	12.74	10.97
Oxygen at base of stack, per cent	5.45	8.15
Carbon monoxide at base of stack, per cent	1.12	0.53
Nitrogen at base of stack (by difference), per cent	80.69	80.35
WATER IN ASH PIT.		
Put in ash pit per pound of dry coal pounds	0.0462	.1454
Accounted for in ashes by analysis, per pound of dry coal, pounds	0.0005	.0032
Evaporated and in flue gases per pound of dry coal, pounds	0.0457	.1421
AIR SUPPLY.		
Theoretical quantity per pound dry coal, pounds	10.817	11.081
Quantity supplied per pound dry coal, pounds	14.656	18.102
Excess air supplied, per cent	35.49	63.36

	Pocahontas.		Bering River.	
	B. t. u.	Per cent.	B. t. u.	Per cent.
HEAT BALANCE BASED ON DRY COAL.				
Heat absorbed by boiler	9,743	65.89	9,481	63.87
Loss due to vaporization of moisture in coal	33	.22	22	.15
Loss due to vaporization of moisture formed from hydrogen in coal	555	3.75	521	3.51
Loss due to heat carried away in dry chimney gases	2,534	17.14	2,802	18.88
Loss due to formation of carbon monoxide	707	4.78	401	2.70
Loss due to combustible in ash and clinker	498	3.37	372	2.51
Loss due to heating moisture in air	26	.18	30	.20
Loss due to vaporization of moisture in ash pit	63	.43	191	1.29
Heat in clinker, radiation and unaccounted for	627	4.24	1,024	6.90
Heating value of 1 pound of dry coal	14,786	100.00	14,844	100.00
HEAT BALANCE BASED ON COMBUSTIBLE.				
Heat absorbed by boiler	10,568	67.43	10,344	65.49
Loss due to vaporization of moisture in coal	36	.23	24	.15
Loss due to vaporization of moisture formed from hydrogen in coal	602	3.84	568	3.60
Loss due to heat carried away in dry chimney gases	2,749	17.54	3,057	19.36
Loss due to formation of carbon monoxide	767	4.89	437	2.77
Loss due to heating moisture in air	28	.18	33	.20
Loss due to vaporization of moisture in ash pit	68	.43	208	1.32
Heat in radiation and unaccounted for	855	5.46	1,123	7.11
Heating value of 1 pound of combustible	15,673	100.00	15,794	100.00

Inclosure P1.

[A. C. Fieldner, chemist.]

Laboratory No. 18347. Can No. 58876.
Test No. 362.
Sample of Pocahontas run-of-mine coal.
Remarks: Duplicate of laboratory No. 18348; sent from Naval Engineering Experiment Station.
Gross weight, 689¼ pounds. Net weight, 1,244.3 grams.
Date of sampling, December 22, 1913. Date of laboratory sampling, December 31, 1913. Date of analysis, January 3, 1914.
For Bureau of Mines section, Navy Department.
Collector, Capt. T. W. Kinkaid.

[Air-dry loss, 1.5.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.90	2.40		
Volatile matter	21.35	21.03	21.55	22.85
Fixed carbon	72.12	71.03	72.77	77.15
Ash	5.63	5.54	5.68	
	100.00	100.00	100.00	100.00
Ultimate analysis:				
Hydrogen	4.57	4.67	4.51	4.78
Carbon	84.23	82.96	85.00	90.12
Nitrogen	1.29	1.27	1.30	1.38
Oxygen	3.46	4.75	2.68	2.84
Sulphur	.82	.81	.83	.88
Ash	5.63	5.54	5.68	
	100.00	100.00	100.00	100.00
Calorific value determined:				
Calories	8,146	8,023	8,220	8,715
B. t. u	14,663	14,441	14,796	15,687
Calorific value calculated from ultimate analysis:				
Calories		8,127		
B. t. u		14,629		

Fusing temperature of ash (in reducing atmosphere): 1,335° C.=2,435° F.
January 27, 1914.

Inclosure P2.

Laboratory No. 18348. Can No. 58871.
Test No. 362.
Sample of Pocahontas run-of-mine coal.
Remarks: Duplicate of laboratory No. 18347; sent from Naval Engineering Experiment Station.
Gross weight, 689¼ pounds; net weight, 1,231.4 grams.
Date of sampling, December 22, 1913. Date of laboratory sampling, December 31, 1913. Date of analysis, January 3, 1914.
For Bureau of Mines section, Navy Department.
Collector, Capt. T. W. Kinkaid.

[Air-dry loss, 1.4.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.90	2.33		
Volatile matter	21.30	20.99	21.49	22.77
Fixed carbon	72.22	71.18	72.88	77.23
Ash	5.58	5.50	5.63	
	100.00	100.00	100.00	100.00
Ultimate analysis:				
Hydrogen	4.51	4.61	4.45	4.72
Carbon	84.12	82.91	84.89	89.96
Nitrogen	1.06	1.04	1.06	1.12
Oxygen	3.98	5.20	3.21	3.39
Sulphur	.75	.74	.76	.81
Ash	5.58	5.50	5.63	
	100.00	100.00	100.00	100.00
Calorific value determined:				
Calories	8,134	8,017	8,209	8,699
B. t. u	14,641	14,431	14,776	15,658
Calorific value calculated from ultimate analysis:				
Calories		8,080		
B. t. u		14,544		

Fusing temperature of ash (in reducing atmosphere): 1,338° C.=2,440° F.
January 21, 1914.

INCLOSURE P3.

Laboratory No. 18351. Can No. 58241.
Test No. 362.
Sample of ashes.
Remarks: From test of Pocahontas coal sent from Naval Engineering Experiment Station.
Gross weight, 147 pounds. Net weight, 988.4 grams.
Date of sampling, December 22, 1913. Date of laboratory sampling, December 31, 1913. Date of analysis, January 5, 1914.
For Bureau of Mines section, Navy Department.
Collector, Capt. T. W. Kinkaid.

[Air-dry loss, 0.7.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.38	1.07		
Volatile matter	5.02	4.99	5.04	8.41
Fixed carbon	54.65	54.27	54.86	91.59
Ash	39.95	39.67	40.10	
	100.00	100.00	100.00	100.00

January 12, 1914.

INCLOSURE P4.

Laboratory No. 18353. Can No. 58879.
Sample of clinker (from grate).
Remarks: From test of Pocahontas coal sent from Naval Engineering Experiment Station.
Gross weight, 75 pounds. Net weight, 1,410.5 grams.
Date of sampling, December 22, 1913. Date of laboratory sampling, January 2, 1914. Date of analysis, January 7, 1914.
For Bureau of Mines section, Navy Department.
Collector, Capt. T. W. Kinkaid.

[Air-dry loss, 2.5.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.05	2.51		
Volatile matter	1.17	1.14	1.17	9.35
Fixed carbon	11.33	11.05	11.34	90.65
Ash	87.45	85.30	87.49	
	100.00	100.00	100.00	100.00

January 12, 1914.

INCLOSURE P5.

Laboratory No. 18356. Can No. 55396.
Test No. 362.
Sample of clinker (from bridge wall).
Remarks: From test of Bering River coal; sent from Naval Engineering Experiment Station.
Net weight, 581.4 grams.
Date of sampling, December 22, 1913. Date of laboratory sampling, December 31, 1913. Date of analysis, January 5, 1914.
For Bureau of Mines section, Navy Department.
Collector, Capt. T. W. Kinkaid.

[Air-dry loss, 0.0.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.15	0.13		
Volatile matter	.88	.88	0.88	
Fixed carbon				
Ash	99.00	99.02	99.15	
	100.03	100.03	100.03	

January 13, 1914.

INCLOSURE P6.

Laboratory No. 18357. Can No. 58242.
Test No. 362.
Sample of soot.
Remarks: From tube and baffle test of Pocahontas coal; sent from Naval Engineering Experiment Station.
Gross weight, 57 pounds. Net weight, 1,124.4 grams.
Date of sampling, December 22, 1913. Date of laboratory sampling, January 5, 1914. Date of analysis, January 9, 1914.
For Bureau of Mines section, Navy Department
Collector, Capt. T. W. Kinkaid.

[Air-dry loss, 37.3.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	1.60	38.30	....	....
Volatile matter	8.88	5.57	9.03	19.43
Fixed carbon	36.84	23.10	37.44	80.57
Ash	52.68	33.03	53.53	....
	100.00	100.00	100.00	100.00

January 13, 1914.

INCLOSURE P7.

Laboratory No. 18349. Can No. 58842.
Test No. 362.
Sample of Bering River screened and washed coal.
Remarks: Duplicate of Laboratory No. 18350; sent from Naval Engineering Experiment Station.
Gross weight, 735¼ pounds. Net weight, 1,218.6 grams.
Date of sampling, December 22, 1913. Date of laboratory sampling, December 31, 1913. Date of analysis, January 6, 1914.
For Bureau of Mines section, Navy Department.
Collector, Capt. T. W. Kinkaid.

[Air-dry loss, 0.7.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.83	1.56	....	....
Volatile matter	17.42	17.29	17.56	18.54
Fixed carbon	76.50	75.94	77.15	81.46
Ash	5.25	5.21	5.29	....
	100.00	100.00	100.00	100.00
Ultimate analysis:				
Hydrogen	4.34	4.39	4.29	4.53
Carbon	85.49	84.86	86.20	91.02
Nitrogen	1.78	1.77	1.80	1.90
Oxygen	2.41	3.05	1.69	1.78
Sulphur	.73	.72	.73	.77
Ash	5.25	5.21	5.29	....
	100.00	100.00	100.00	100.00
Calorific value determined:				
Calories	8,187	8,126	8,254	8,715
B. t. u.	14,737	14,627	14,857	15,687
Calorific value calculated from ultimate analysis:				
Calories	....	8,255	....	....
B. t. u.	....	14,859	....	....

Fusing temperature of ash (in reducing atmosphere): 1,380°C.=2,516°F.
January 21, 1914.

INCLOSURE P8.

Laboratory No. 18350. Can No. 58837.
Test No. 362.
Sample of Bering River screened and washed coal.
Remarks: Duplicate of laboratory No. 18349; sent from Naval Engineering Experiment Station.
Gross weight, 735½ pounds. Net weight, 1,243.2 grams.
Date of sampling, December 22, 1913. Date of laboratory sampling, December 31, 1913. Date of analysis, January 6, 1914.
For Bureau of Mines section, Navy Department.
Collector, Capt. T. W. Kinkaid.

[Air-dry loss 0.8.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.80	1.60	....	....
Volatile matter	17.35	17.21	17.49	18.52
Fixed carbon	76.35	75.73	76.96	81.48
Ash	5.50	5.46	5.55	....
	100.00	100.00	100.00	100.00
Ultimate analysis:				
Hydrogen	4.37	4.42	4.31	4.56
Carbon	84.91	84.22	85.59	90.62
Nitrogen	1.79	1.78	1.81	1.92
Oxygen	2.69	3.39	2.00	2.12
Sulphur	.74	.73	.74	.78
Ash	5.50	5.46	5.55	....
	100.00	100.00	100.00	100.00
Calorific value determined:				
Calories	8,173	8,107	8,239	8,723
B. t. u.	14,711	14,593	14,830	15,701
Calorific value calculated rom ultimate analysis:				
Calories	....	8,200	....	....
B. t. u.	....	14,760	....	....

Fusing temperature of ash (in reducing atmosphere): 1,353° C.=2,467° F.
January 21, 1914.

INCLOSURE P9.

Laboratory No. 18352. Can No. 58844.
Test No. 362.
Sample of ashes.
Remarks: From test of Bering River coal; sent from Naval Engineering Experiment Station.
Gross weight, 95½ pounds. Net weight, 1,073.5 grams.
Date of sampling, December 22, 1913. Date of laboratory sampling, January 3, 1914. Date of analysis, January 7, 1914.
For Bureau of Mines section, Navy Department.
Collector, Capt. T. W. Kinkaid.

[Air-dry loss, 9.0.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.35	9.28	....	....
Volatile matter	5.93	5.40	5.95	12.92
Fixed carbon	39.97	36.39	40.11	87.08
Ash	53.75	48.93	53.94	....
	100.00	100.00	100.00	100.00

January 12, 1914.

INCLOSURE P10.

Laboratory No. 18354. Can No. 55427.
Test No. 362.
Sample of clinker (from grate).
Remarks: From test of Bering River coal; sent from Naval Engineering Experiment Station.
Gross weight, 138 pounds. Net weight, 1,358.7 grams.
Date of sampling, December 22, 1913. Date of laboratory sampling, January 2, 1914. Date of analysis, January 7, 1914.
For Bureau of Mines section, Navy Department.
Collector, Capt. T. W. Kinkaid.

[Air-dry loss, 4.7.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.13	4.82		
Volatile matter	1.87	1.78	1.87	9.65
Fixed carbon	17.47	16.65	17.50	90.35
Ash	80.53	76.75	80.63	
	100.00	100.00	100.00	100.00

January 12, 1914.

INCLOSURE P11.

Laboratory No. 18355. Can No. 58880.
Test No. 362.
Sample of clinker (from bridge wall).
Remarks: From test of Pocahontas coal; sent from Naval Engineering Experiment Station.
Gross weight, 18 pounds. Net weight, 1,472.5 grams.
Date of sampling, December 22, 1913. Date of laboratory sampling, December 31, 1913. Date of analysis, January 5, 1914.
For Bureau of Mines section, Navy Department.
Collector, Capt. T. W. Kinkaid.

[Air-dry loss, 1.2.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.18	1.40		
Volatile matter	.97	.96	.97	10.90
Fixed carbon	7.92	7.82	7.93	89.10
Ash	90.03	89.82	91.10	
	100.00	100.00	100.00	100.00

January 12, 1914.

INCLOSURE P12.

Laboratory No. 18358. Can No. 58861.
Test No. 362.
Sample of soot.
Remarks: From tubes and baffle test of Bering River coal; sent from Naval Engineering Experiment Station.
Gross weight, 33½ pounds. Net weight, 697.6 grams.
Date of sampling, December 22, 1913. Date of laboratory sampling, December 31, 1913. Date of analysis, January 5, 1914.
For Bureau of Mines section, Navy Department.
Collector, Capt. T. W. Kinkaid.

[Air-dry loss, 0.3.]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Proximate analysis:				
Moisture	0.90	1.23		
Volatile matter	9.20	9.17	9.28	18.98
Fixed carbon	39.25	39.12	39.61	81.02
Ash	50.65	50.48	51.11	
	100.00	100.00	100.00	100.00

January 12, 1914.

FINDINGS, COMMENTS, AND OPINIONS OF THE NAVY DEPARTMENT.

The geological and mining conditions in the Bering River fields are unfavorable in that they oblige high mining costs. In general, the coal measures are much disturbed, the field having been subjected to intense dynamic stresses, resulting in folding, faulting of the strata, and crushing of the coal. It is the opinion of the best authorities that the mining conditions in the field are less favorable than those pertaining in the United States, with the exception of a certain area in the State of Washington. Added to this, and to the steep dips of the coal measures, is the necessity of expensive mine timbering, and of more than ordinary mine ventilation and drainage. Moreover, a very heavy rainfall, aside from its effect on general conditions, will result in very wet coal as delivered at the terminals. The latter can not be dismissed as a small matter; for a moisture content of 5 per cent in coal will result in a battleship loading 100 tons of water in her bunkering of 2,000 tons—a loss of one day's steaming at 12 knots and a consequent loss in cruising radius of 288 miles. This, of course, may and should be guarded against; but it means further additional increase in the already high mining and transportation costs noted below.

PRICE AT WHICH BERING RIVER COAL CAN BE LAID DOWN AT SAN FRANCISCO AND SEATTLE.

There exists a wide discrepancy between the Bureau of Mines' estimate of mining costs and the estimates of other mining engineers who have examined the field, the main differences being the large timbering charge in the former's estimate. At this time when there has been practically no mining in these fields, it is impossible to reconcile these differences of opinion; and hence the department will here quote the maximum and minimum estimates in order that some conclusion may be drawn from the most favorable and most unfavorable conditions:

	Maximum.				Minimum.			
	Bureau of Mines' mining cost estimates.		Mr. A. H. Storr's mining cost estimates.		Bureau of Mines' mining cost estimates.		Mr. A. H. Storr's mining cost estimates.	
	To Seattle.	To San Francisco.	To Seattle.	To San Francisco.	To Seattle.	To San Francisco.	To Seattle.	To San Francisco.
Mining costs	[1] $3.35	[1] $3.35	[2] $1.96	[2] $1.96	[3] $2.60	[3] 2.60	[2] $1.93	[2] $1.93
Haulage to Cordova, including wharfage (Alaskan R.R.Commission)	1.42	1.42	1.42	1.42	.95	.95	.95	.95
Ocean freights (Navy Department estimates)	1.25	1.75	1.25	1.75	1.16	1.52	1.16	1.52
Unloading charge	.165	.165	.165	.165	.165	.165	.165	1.165
Total	6.185	6.685	4.795	5.295	4.875	5.235	4.205	4.565

[1] Includes a charge of $0.30 for washing; also charges for royalty and depreciation of plant.

[2] Includes charge for exhaustion of lands and charge for interest and depreciation, but does not include washing charge.

[3] Does not include above.

NOTE.—The estimates for mining costs are for actual costs only and do not include a direct or indirect profit for the operator.

To afford a basis of comparison, a maximum and a minimum of Pocahontas cost at San Francisco is appended:

Item.	Maximum.	Minimum.
Pocahontas, f. o. b. Norfolk	$3.00	$3.00
Ocean freights	[1] 3.90	[2] 2.45
Unloading charge	.165	.165
Total	7.065	5.615

[1] Navy Department estimates. If interest and depreciation be omitted in this estimate (as it would should naval colliers be employed), the ocean freights would be $2.57 and the total $5.735 per ton.

[2] Prof. E. R. Johnson: Report of the Isthmian Canal Commission, S. Doc. 54, pt. 2, 1902. Appendix N. N., p. 349.

Of the above discrepancy, it may be said that the lowest estimate received from an eastern coal company for delivery of Pocahontas at San Francisco is $6.87 per ton.

COMPARISON.

From the foregoing it can be seen that if the Navy Department's and the coal company's estimates of the price of Pocahontas at San Francisco be accepted, Bering River coal will in all cases undersell Pocahontas in the Pacific coast market; while if Prof. E. R. Johnson's estimate and the Navy Department's interest-and-depreciation-free estimates be accepted, Bering River coal will undersell Pocahontas in all cases except in the event that the first estimate, i. e., the Bureau of Mines maximum, proves to be the true one. It seems reasonable to the department that during the first few years of the construction and operation of the Alaskan railroad, and of the opening of the coal fields to development that the Bureau of Mines maximum estimate will probably obtain; nevertheless, the most probable Pocahontas rates indicate that Bering River coal will undersell Pocahontas. If an average be struck of all rates quoted above, it will appear that Bering River coal can be laid down at San Francisco for $5.445, against $6.34 Pocahontas. It can thus be seen that were Bering River coal suitable for naval use a saving of $258,500 per year could be effected by its use, on an estimated annual need of 300,000 tons, and a vast strengthening of national security attained at the same time by the lessening of transportation difficulties in time of war.

RESULTS OF STEAMING TESTS.

It is with regret, then, that the department reports that the recent tests show conclusively that Bering River coal, mined from selected veins in one of the most promising portions of the field, is entirely unsuitable for naval use. Formerly the defect that gave the greatest concern was the general crushed condition of the coal, from which a large percentage of slack might be expected. An adequate percentage of lump was found, however, although it developed that much if not all of the slack must be washed, for it appears impossible for the miner to avoid knocking down the black shale bands with the coal, and the separation of these impurities from the coal is not practicable in any other way than by washing—which increases the cost of mining while not overcoming the inherent objections to slack coal.

The coal, however, failed on account of its property of forming large, tenacious clinker—probably the most serious defect that can be developed by a coal for marine use. Whether or not a nonclinkering coal of good chemical and physical qualities exists in the field is an unsolved problem, The Bering River sample tried by the *Nebraska* in 1908 did not clinker at the low rate of combustion and consequent low furnace temperatures pertaining during that inconclusive trial. However, neither did the Bering River coal recently tested clinker under natural draft. Coal from that part of the field from which the *Nebraska* sample was mined is generally slack, and apparently not in this respect equal in physical qualities to the all-around satisfactory grade which it is hoped may be found.

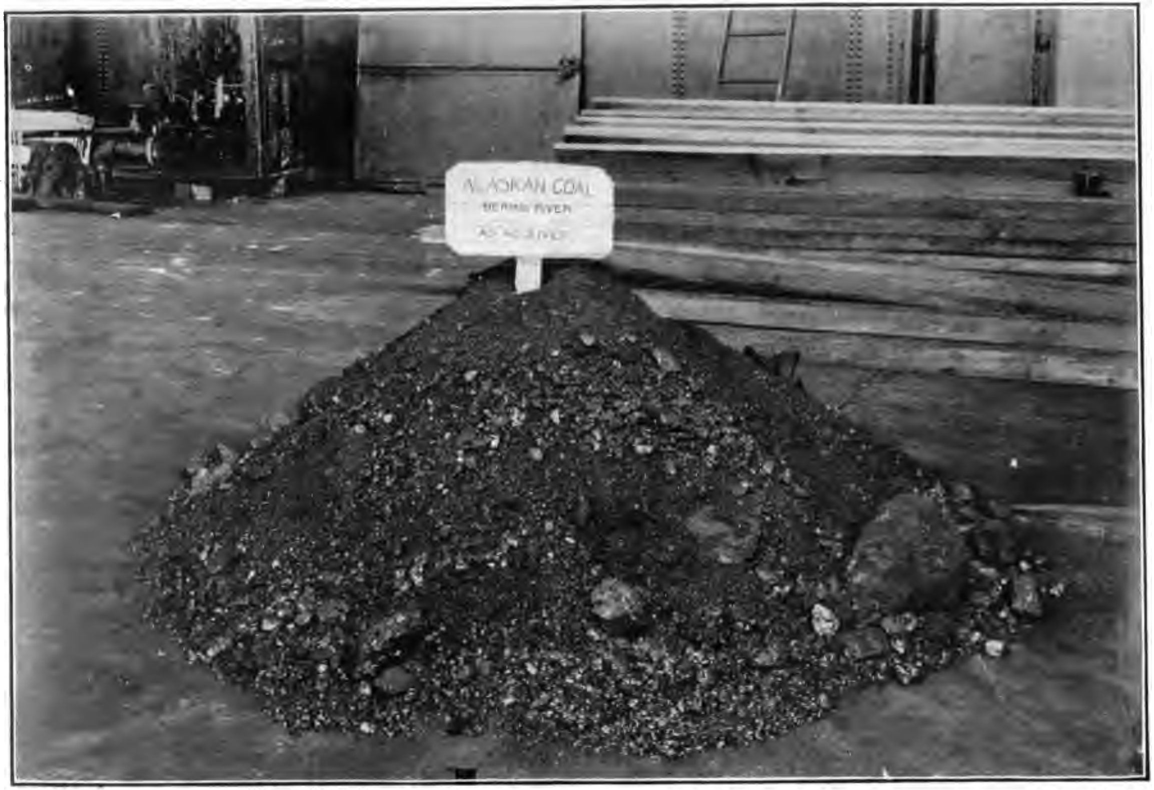
GENERAL COMMENT AND RECOMMENDATIONS.

It thus appears that in a field like the Bering River, where in a comparatively small area anthracite, semianthracite, and semibituminous coals are found, and moreover where the measures have been so extensively disturbed, lack of uniformity in grade may be expected. It seems, therefore, that if coal suitable for naval use exists, it can not be spotted by chemical or physical excellence, but must be searched out by the laborious and expensive, but conslusive, methods of trial under service conditions.

The clinkering of coal is a subject on which but little of value is known from analysis. It varies with the type of grate, rate of combustion, depth of fire, and draft, so that the only positive guide as to its existence, nonexistence, or extent is a trial under the actual conditions under which the coal will be used. For this reason, the department would not regard a field test for clinkering—analyzing, taking temperatures of ash fusibility, tests in small grates or boilers—as information of any positive value. This procedure would be expensive and the results probably misleading. Now that the Alaskan railroads will be built, and a line extended into the Bering River fields, and the coal fields probably opened to leasing, the further test of coal from these fields for naval use should be resumed as soon as possible after the completion of the road, and after general development has set in in the coal fields, by the trial of large samples (cargoes) from various seams. In this manner only, in the department's opinion, can the existence of a satisfactory coal for naval use be ascertained.

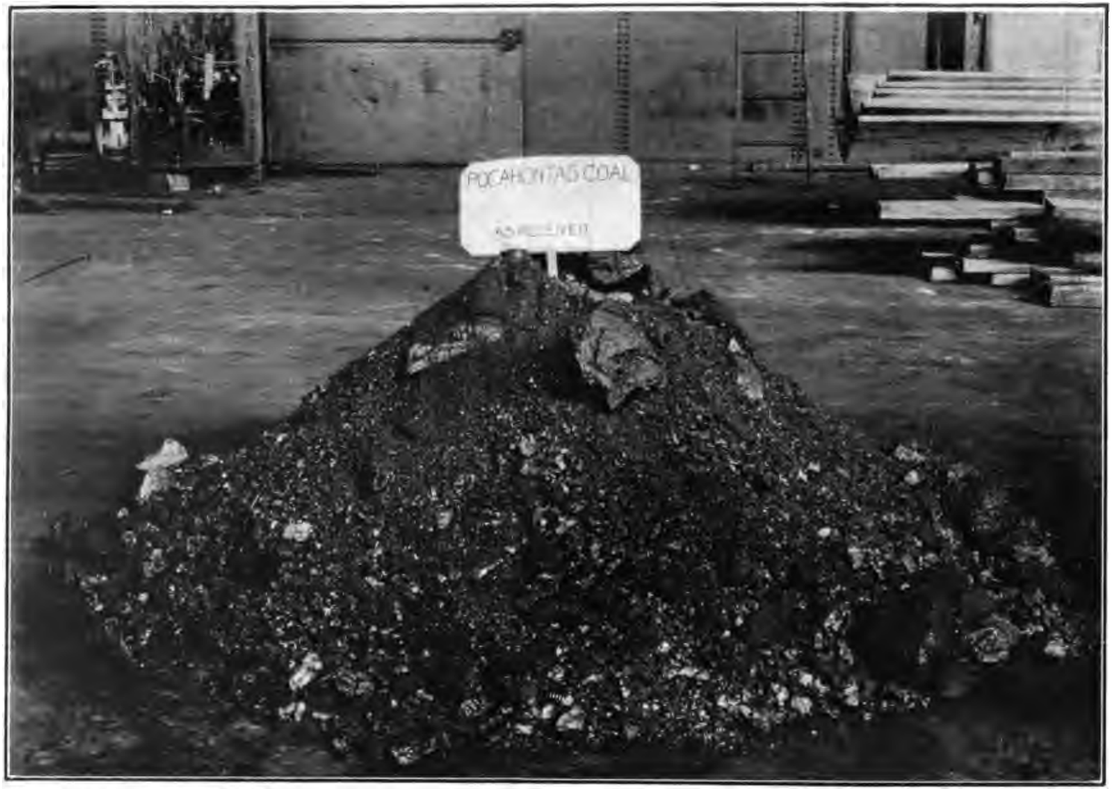
CONCLUSION.

In conclusion, the failure on test of the excellent Bering River sample at the Engineering Experiment Station from severe and unusual clinkering—a sample better in all respects than the Pocahontas used in comparative test—obliges the department to regard and so report the Bering River field to be unavailable as a source of coal for the Navy until extensive general development definitely locates coal not possessing the serious objection found in the sample tested by the department.



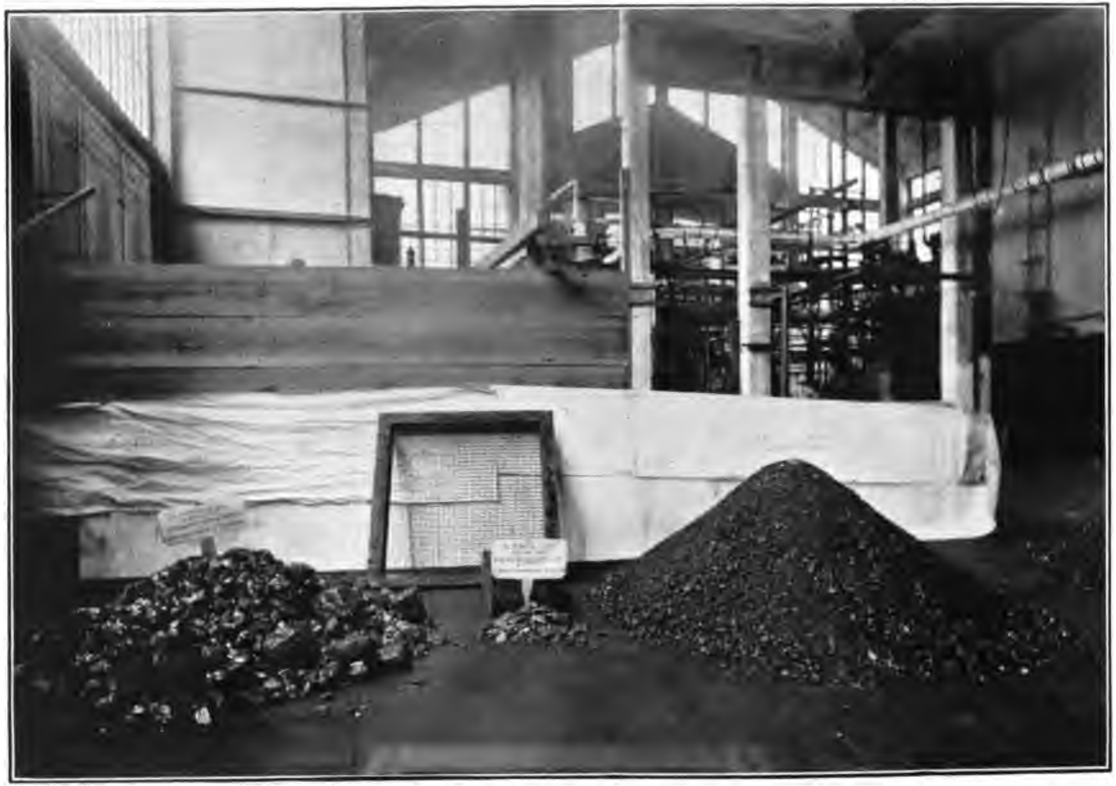
BERING RIVER COAL AS RECEIVED.

U. S. Naval Engineering Experiment Station, Annapolis, Md. Test No. 362. (Inclosure "E.")



POCAHONTAS COAL AS RECEIVED.

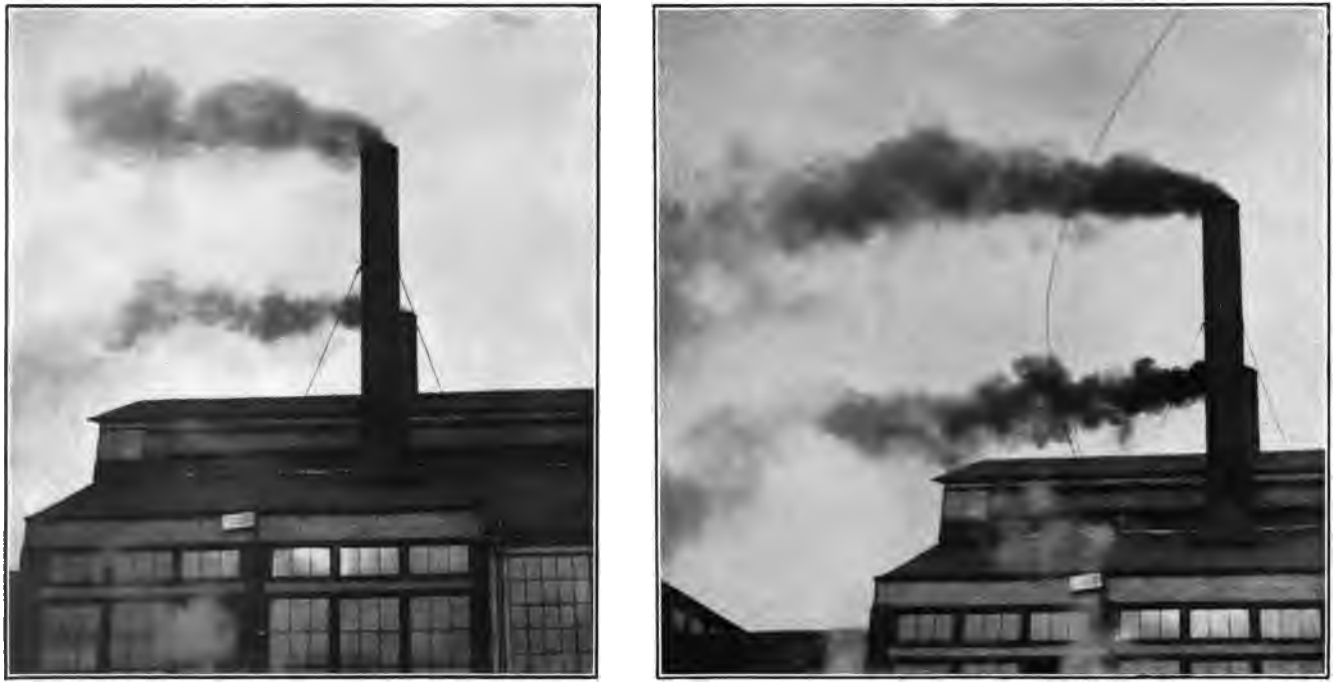
U. S. Naval Engineering Experiment Station, Annapolis, Md. Test No. 362. (Inclosure F.)



Over $\frac{7}{8}$-inch screen, 25.4 per cent. Slate, 0.9 per cent. Through $\frac{7}{8}$-inch screen, 73.7 per cent.

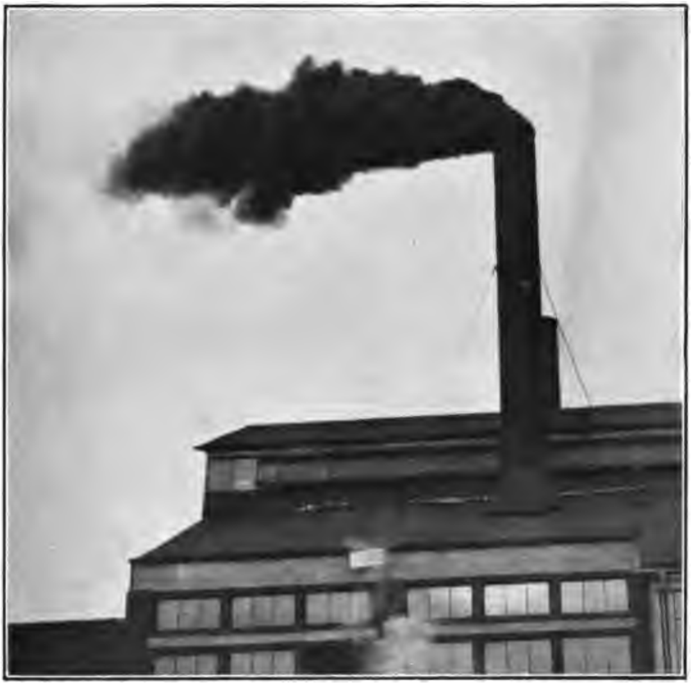
SCREENED BERING RIVER COAL.

U. S. Naval Engineering Experiment Station, Annapolis, Md. Test No. 362. (Inclosure G.)



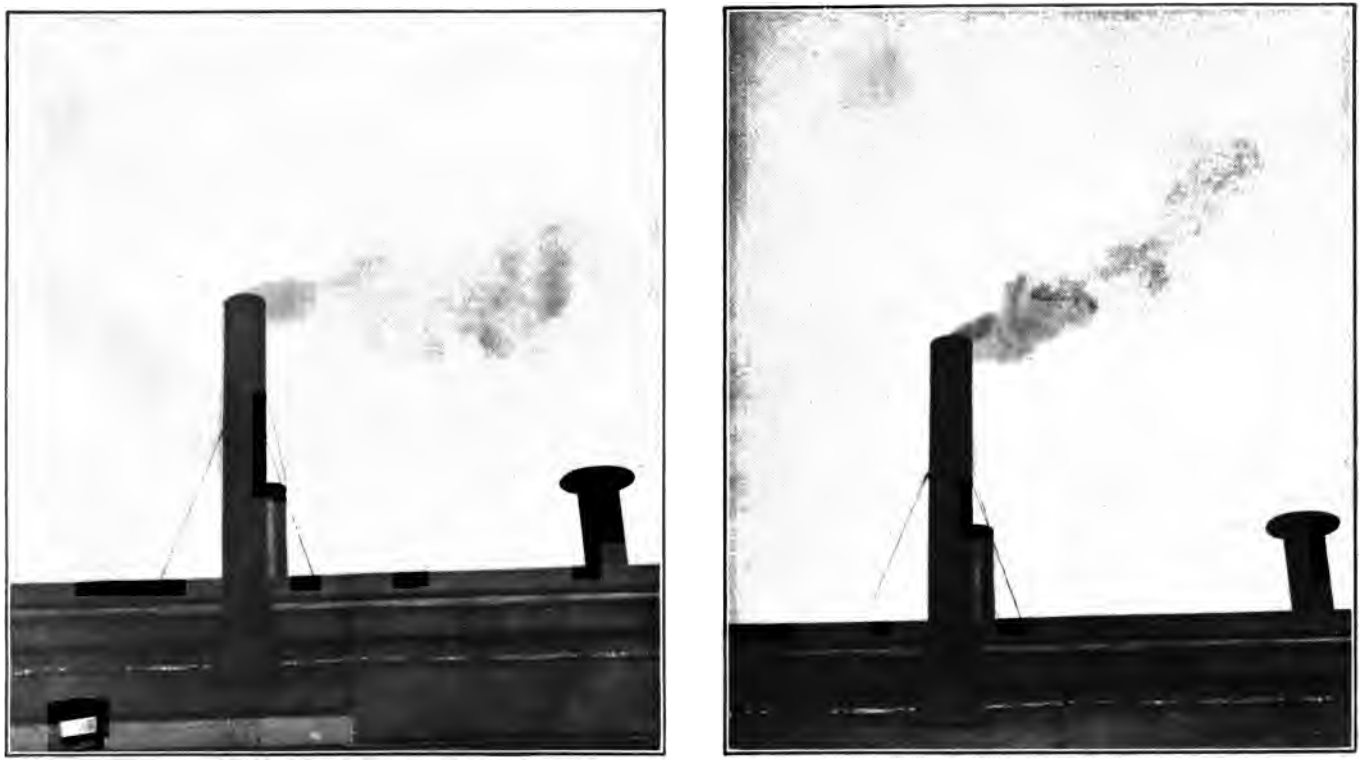
SMOKE FROM POCAHONTAS COAL.

U. S. Naval Engineering Experiment Station, Annapolis, Md. Test No. 362. (Inclosure Q-1.)



SMOKE FROM POCAHONTAS COAL.

U. S. Naval Engineering Experiment Station, Annapolis, Md. Test No. 362. (Inclosure Q-1.)

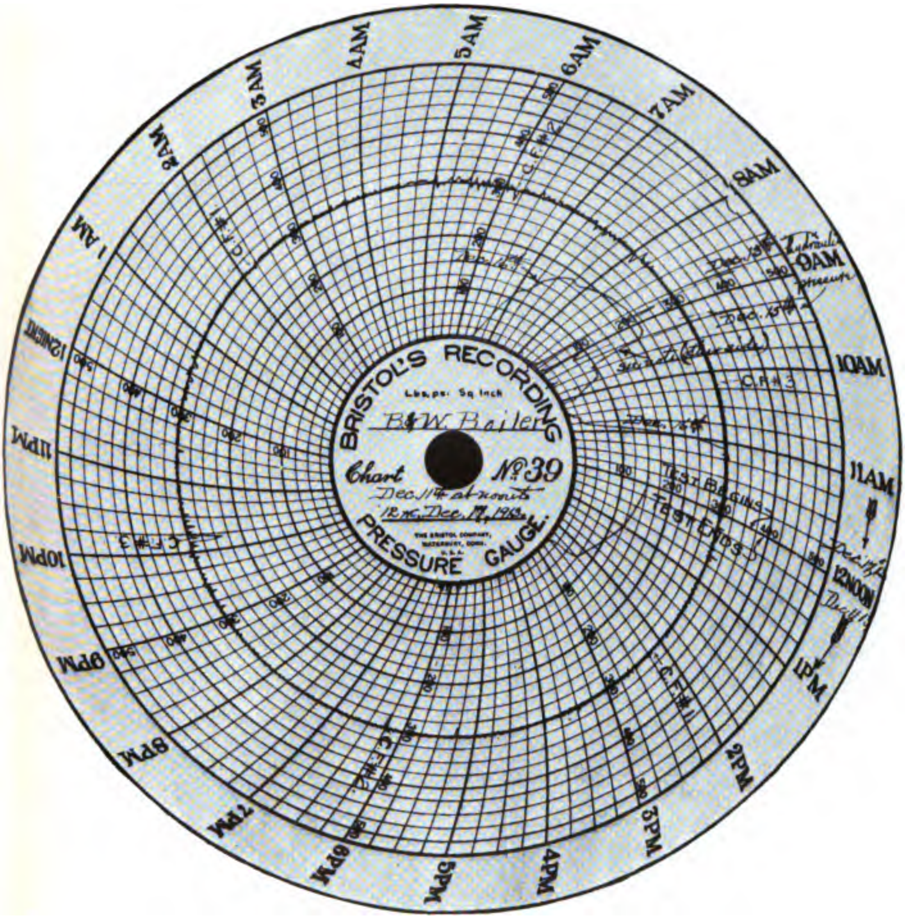


SMOKE FROM BERING RIVER COAL.

U. S. Naval Engineering Experiment Station, Annapolis, Md. Test No. 362. (Inclosure Q-2.)

PRESSURE GAUGE CHART.

U. S. Naval Engineering Experiment Station, Annapolis, Md. Test No. 362. (Inclosure R.)



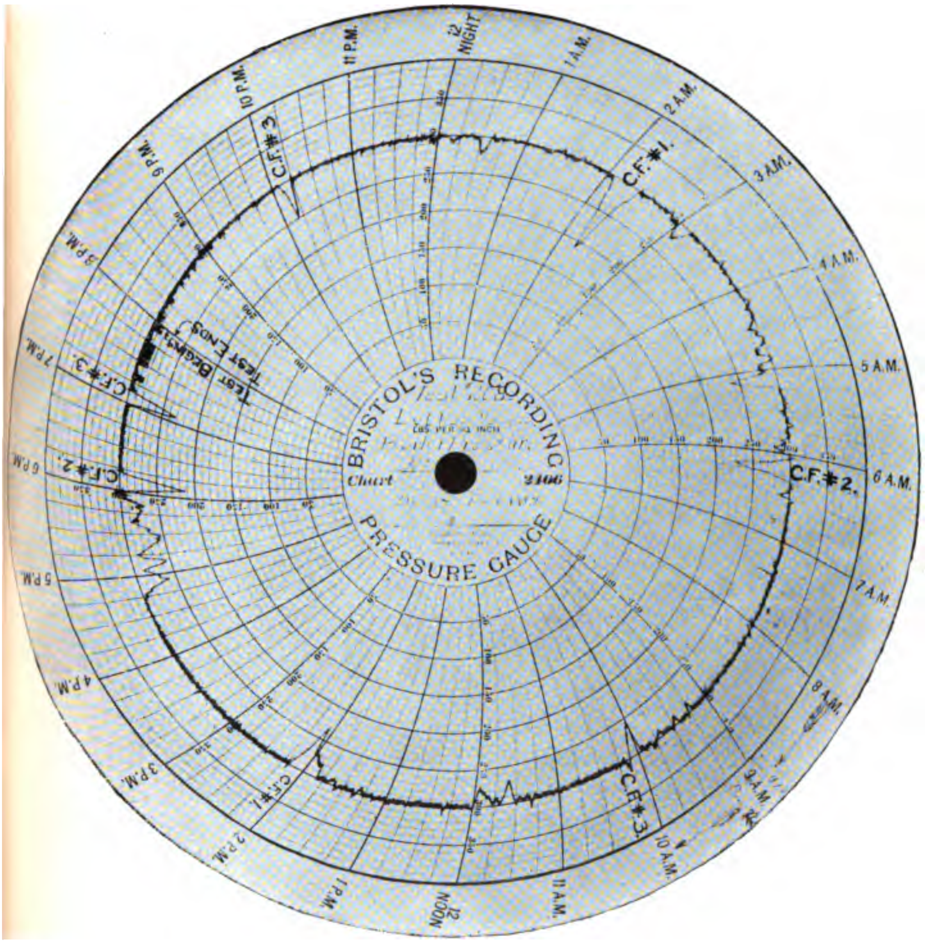
POCAHONTAS COAL TEST.

December 16–17, 1913.

H. Doc. 876, 63–2.

PRESSURE GAUGE CHART.

U. S. Naval Engineering Experiment Station, Annapolis, Md. Test No. 362. (Inclosure R.)



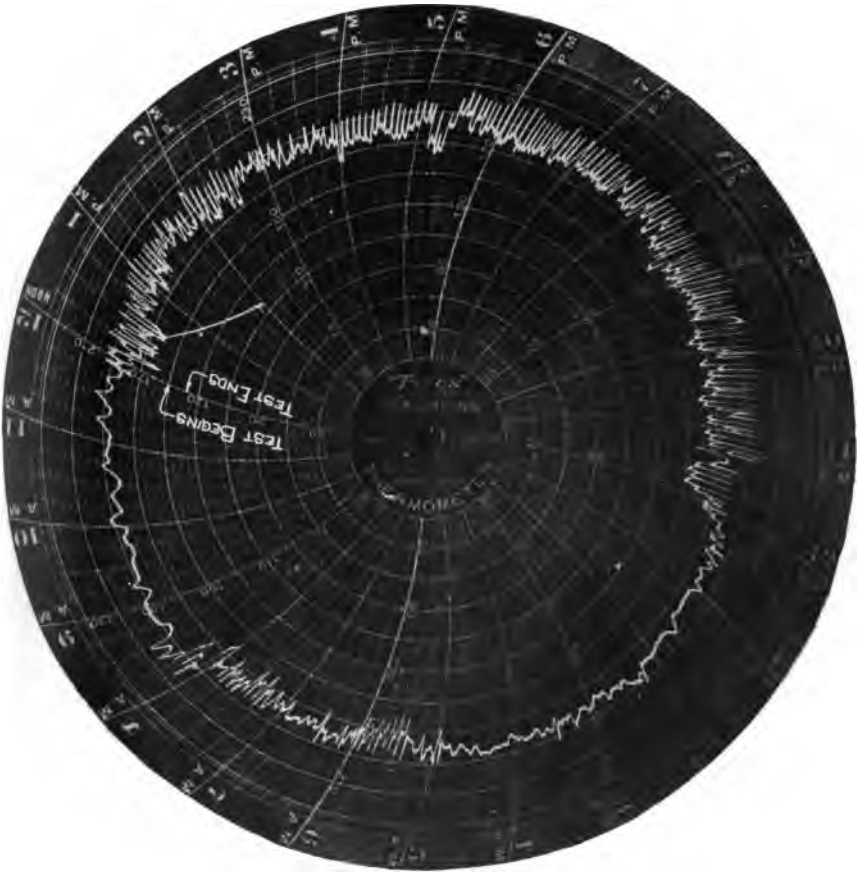
BERING RIVER COAL TEST.

December 17-18, 1913.

H. Doc. 876, 63-2.

FEED TEMPERATURE CHART.

U. S. Naval Engineering Experiment Station, Annapolis, Md. .Test No. 362. (Inclosure S.)



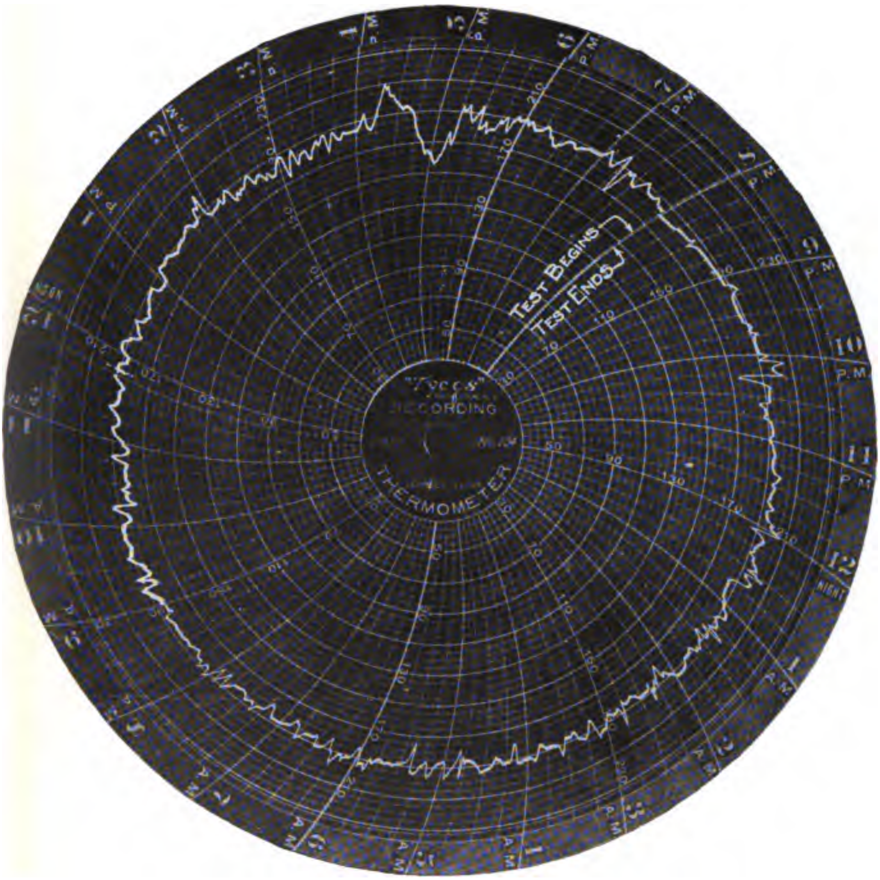
POCAHONTAS COAL TEST.

December 16-17, 1913.

H. Doc. 876, 63-2.

FEED TEMPERATURE CHART.

U. S. Naval Engineering Experiment Station, Annapolis, Md. Test No. 362. (Inclosure S.)

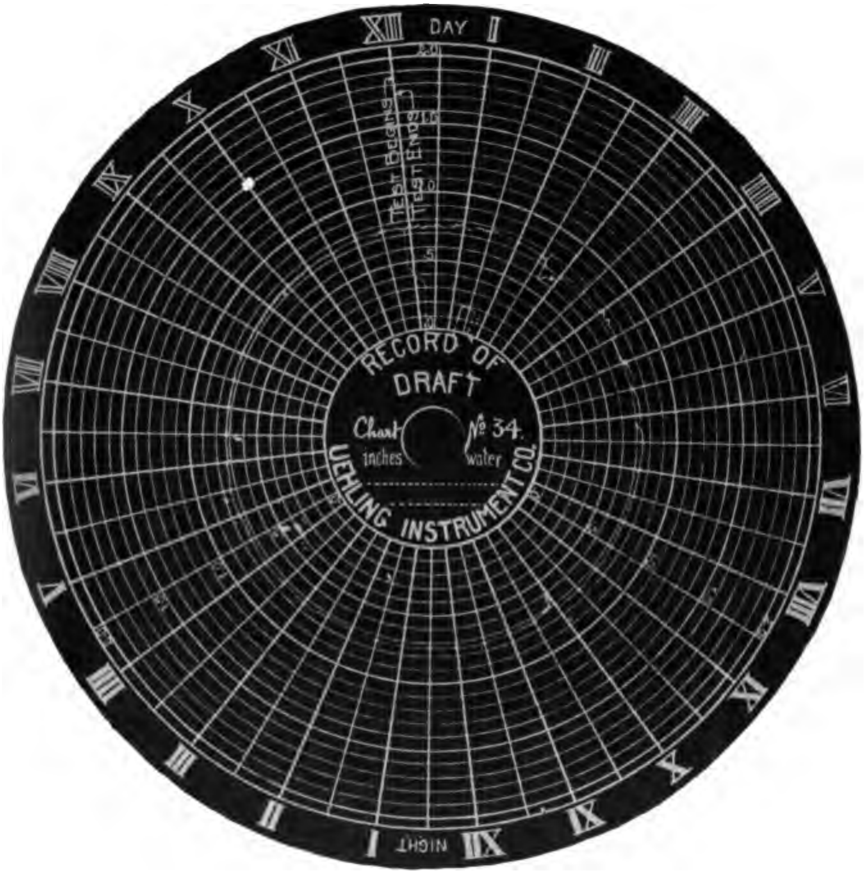


BERING RIVER COAL TEST

December 17-18, 1913.

STACK DRAFT CHART.

U. S. Naval Engineering Experiment Station, Annapolis, Md. Test No. 362. (Inclosure T.)



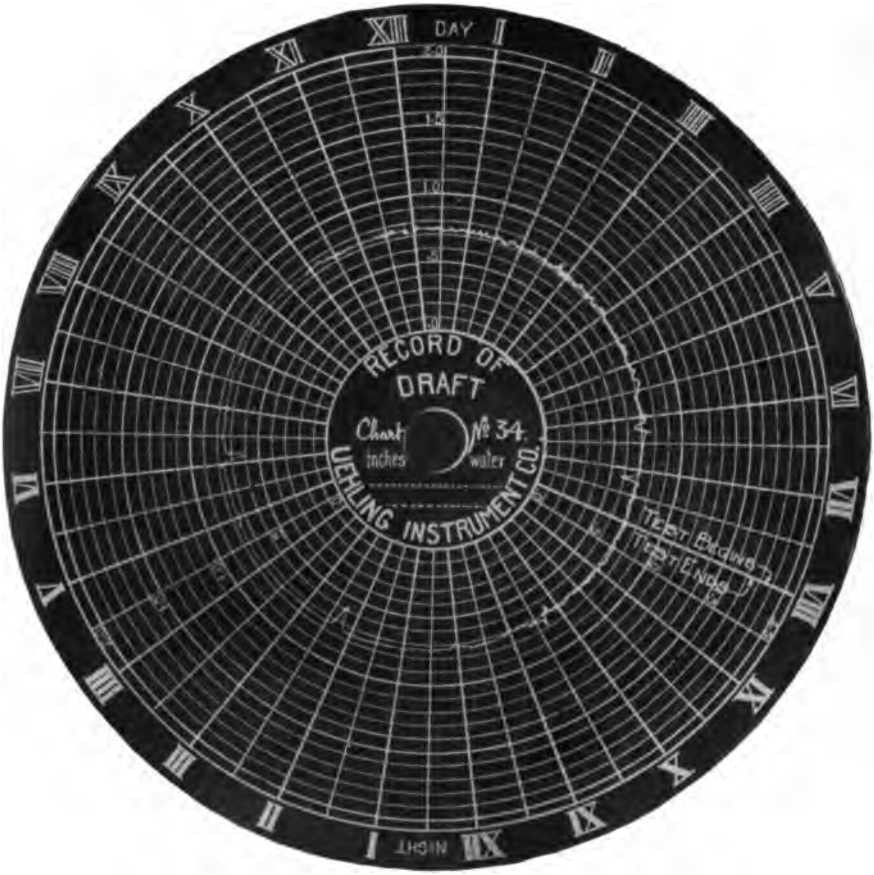
POCAHONTAS COAL TEST.

December 16–17, 1913.

H. Doc. 876, 63-2.

STACK DRAFT CHART.

U. S. Naval Engineering Experiment Station, Annapolis, Md. Test No. 362. (Inclosure T.)



BERING RIVER COAL TEST.

December 17-18, 1913.

DATE DUE

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Report on coal in Alaska for use in
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